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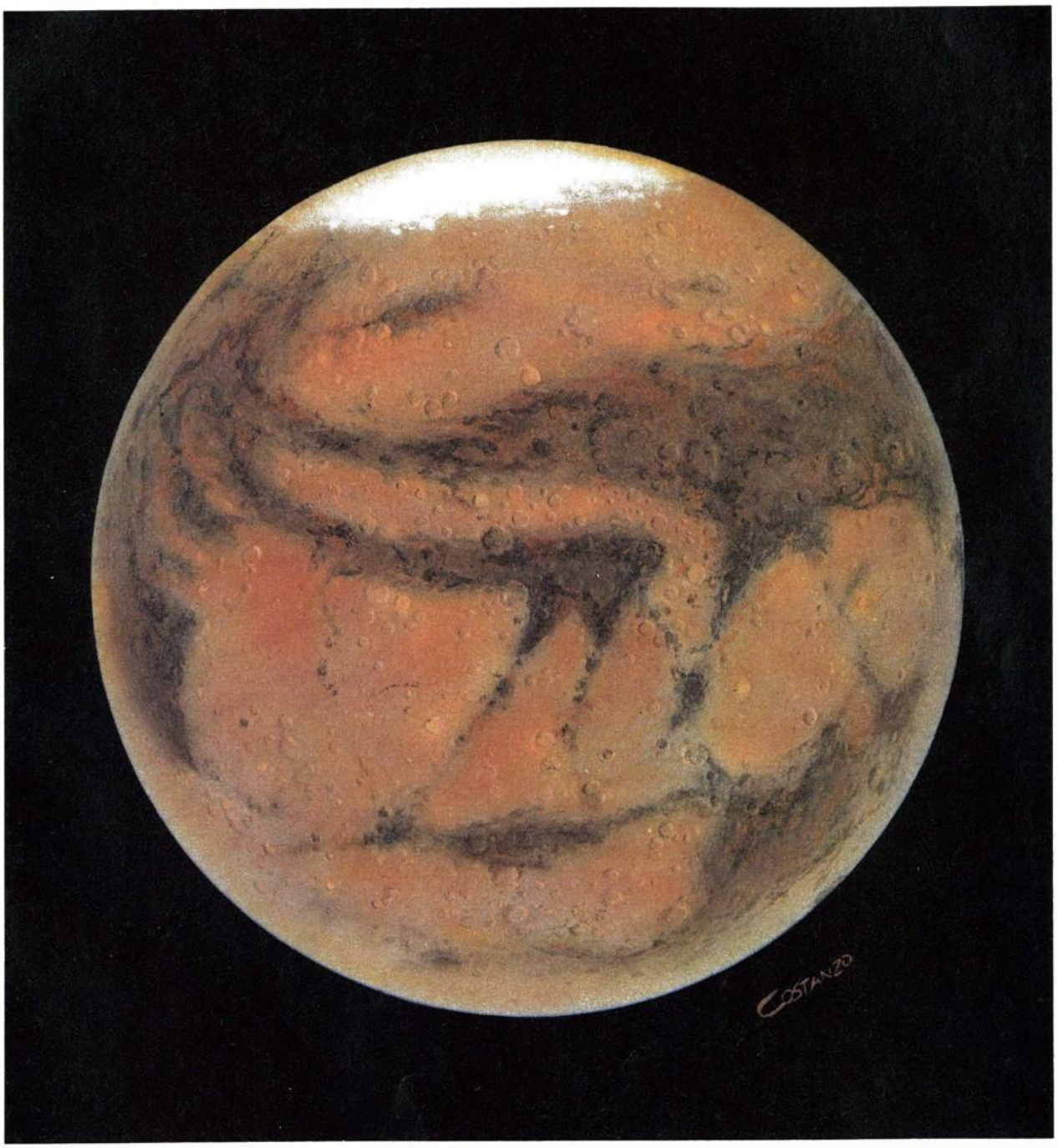

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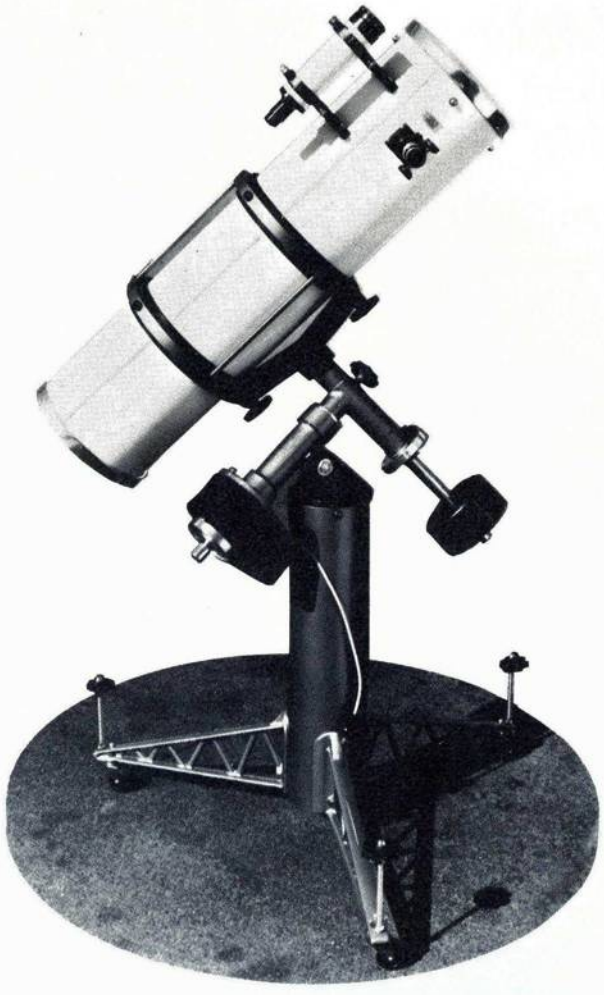

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ASTRONOMY

The World's Most Beautiful Astronomy Magazine

September 1973 Vol. 1, No. 2

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Cover Art -

Mars might look like this when viewed through a small telescope aboard a manned mission in the vicinity of the red planet in the 21st century. This rendering also approximates the view that will be obtained from earth orbit once the 120 inch space telescope project is operational in the 1980's. Painting by Victor Costanzo, Strasenburgh Planetarium, Rochester Museum and Science Center. See feature, "The Surface of Mars", by Neale E. Howard, and Gazer's Gazette, "Observing Mars in 1973", by Terence Dickinson.

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The Surface of MARS

by

Neale E. Howard

The "new" geography of Mars is perhaps an old story now, yet to many people the previously unsuspected features of the Martian surface are still a source of excitement and speculation.

Some of these features are so extensive that it is even possible they may be spotted by earth-bound large-aperture telescopes, now that astronomers know exactly where to look. Of course it is still impossible to photograph any of the new discoveries since Earth's shifting atmosphere reduces the resolving capabilities of telescopes and blurs detail that might otherwise be seen.

An especially good view of the planet will occur in the last half of October — opposition occurs on the 26th although Mars is actually closest to us on the 17th — when the orbits of Earth and Mars close to a distance of about 42 million miles. Hopefully, good seeing conditions on both planets will coincide; if this chance is missed, the next won't come until 1988.

The question naturally arises: if these features are so large and conspicuous, why haven't they been seen before? Observers using telescopes such as the 82 inch reflector at McDonald Observatory have spotted Martian detail only 20 miles in width, using the telescope visually, yet objects hundreds of times larger have been missed completely. There seem to be several reasons, not the least of which is the refusal of the observer to believe his eyes. Who, for example, would expect to see a volcano whose base is so large it could cover a dozen Texas counties? Or a mighty canyon which could stretch from Labrador to Key West?

Probably, however, physical causes are better reasons for our failure to see detail. The Martian surface is often obscured by clouds, dust storms, or the settled dust from these storms. Our own atmosphere is rarely quiet enough — or clean enough — for us to observe fine detail through it. Martian features are seldom outlined against a contrasting background. The result is a sort of protective coloration of the kind which makes it difficult to see a woodcock against a cover of autumn leaves.

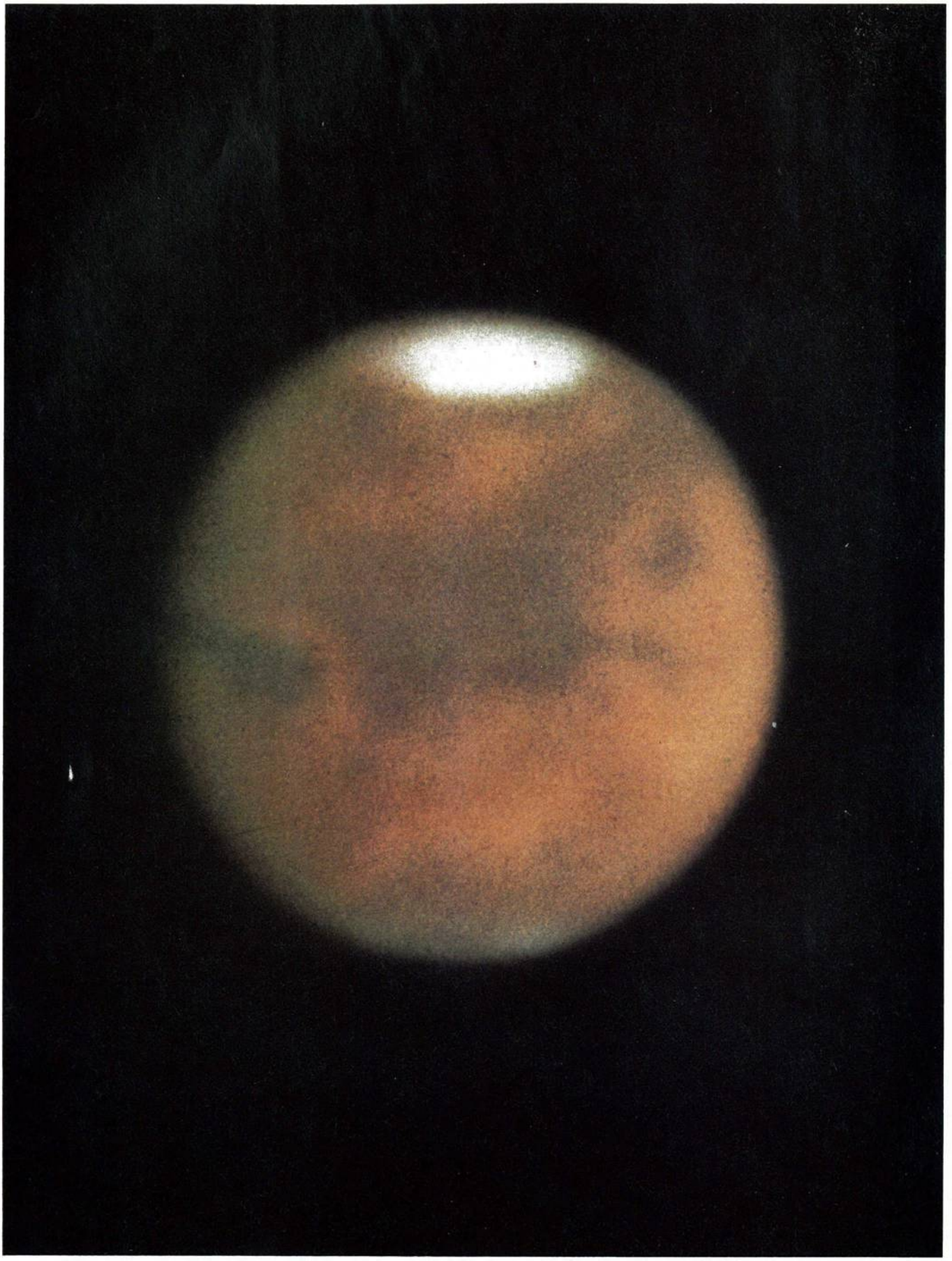
NASA Photograph

This segment of a Martian riverbed is about 50 miles long. It is located just north of the equator in the Amazonis region. The water it once contained flowed from lower left toward upper right.

This is all very discouraging for anyone who owns a small telescope, for his hope of seeing anything more than fuzzy patches on Mars is indeed a remote one. Nevertheless, it is still exciting to know that in those fuzzy patches lie some of the most interesting objects in our solar system.

Up to a year or so ago most scientists thought of the surface of Mars as an arid pockmarked expanse covered at the poles by a thin layer of dry ice. This was largely because the previous Mariners — 4, 6 and 7 — scanned only those sections of its 55 million square miles where such features predominated.

Now the picture is changed. Mariner 9 photographs show us a rough, mountainous planet, eroded in places by water, scoured by dust-filled gales and dotted with huge volcanoes as well as impact craters made by meteorites. Mars' valleys are deeper and its mountains higher than those on Earth. The crust of the planet is constantly in motion, shifting in the same way as the continents of Earth once moved. The rifts produced in this way are immense by Earth's standards. One in particular in the Coprates region is 2,300 miles long and many times deeper and wider than the Grand Canyon. The planet itself is misshapen; its



Lunar & Planetary Laboratory Photograph

Photograph by Steven Reed

The above photograph of Mars approximates what an observer might see through an eight inch reflector telescope. Compare this photograph with the Lunar and Planetary Laboratory photograph on the opposite page. Since both photographs are centered on Aurorae Sinus, they offer an excellent opportunity to compare what can be seen through an amateur and observatory telescope. (Compare features with the map of Mars on Page 30.)

south polar region bulges, while the north pole is depressed. The equatorial region also bulges, notably in the dark area we call Syrtis Major and in the volcanic section, Tharsis.

Mars is presently an arid planet, although it has not always been that way. All the water in its thin atmosphere, if condensed on the surface, would form a layer only 10 to 20 microns deep. This is less than the thickness of a very thin sheet of tissue paper. There must have been very much more of this in the past. The sinuous and branching channels in Mare Erythraeum and in other sections resemble their Earth counterparts to such an extent that there can be little doubt they were formed by water. Elsewhere there are myriads of smaller channels which look as though they are the result of heavy rainfall.

The surface of Mars contains a variety of geological forms. At the center of Mars' disk in the photograph on the opposite page is Erythraeum Mare and Aurorae Sinus. The south polar cap at top is well developed, while the north polar cap is barely visible. (The photograph was made during summer in Mars' northern hemisphere.) The darkest area on the planet's left (eastern) limb is Meridiani Sinus — the sun had just set on Syrtis Major when this Lunar and Planetary Laboratory photograph was made. The telescope used was a 61 inch reflector.

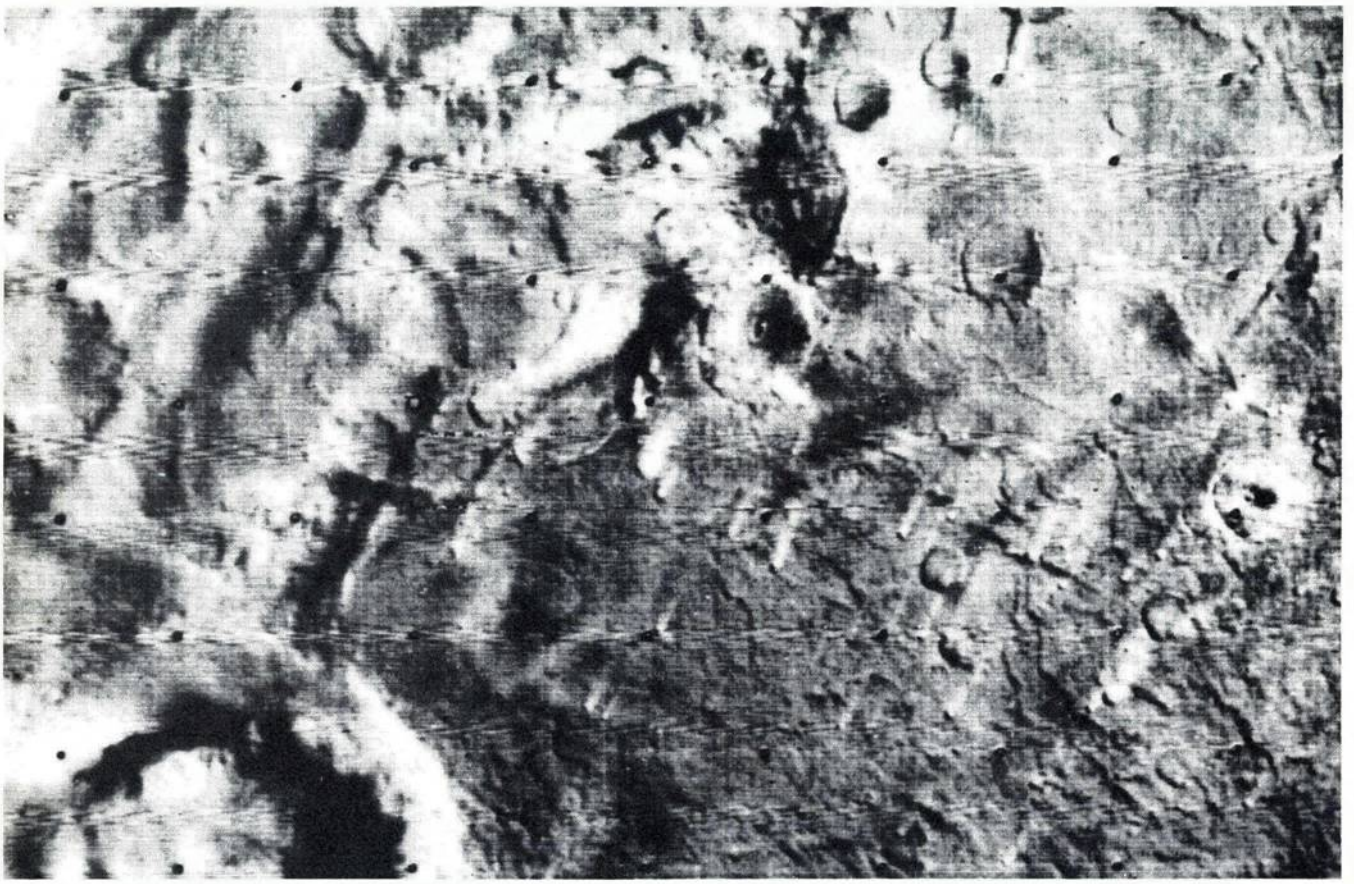
Where did the water come from? There are several possible theories. Dr. Harold Masursky has suggested that Mars has had glacial periods like Earth, except in reverse. He thinks that Mars is constantly cold but has had occasional periods of warmth. Like Earth, Mars wobbles on its axis, completing a precessional cycle every 50 thousand years. During the cycle the great polar icecaps build up, perhaps to a thickness of several miles. The accumulation alternates, first at one pole, then at the other. In between there may be a period of instability in which moisture occurs in

the atmosphere, finally falling as rain. Simultaneously, the permafrost beneath the surface melts and water vapor is expelled, some of it through volcanic vents, some of it through cracks and rifts in the surface material. Another theory depends upon a change in the orbit of Mars which appears to happen in two cycles, one occurring at 95 thousand year intervals and the other every two million years. If an orbital change coincides with the precessional cycle, very great amounts of moisture, falling as rain, would result.

But if there has been water in the past, where is it now? Water molecules in gaseous form are in constant motion at very high speeds, on the average about 1/2 mile per second. This is close enough to the escape velocity of the planet that some of the molecules may simply bounce out into space in the same way that the moon has lost its atmosphere. It is also likely that water molecules in the upper atmosphere of the planet may be broken up in photochemical reactions triggered by ultraviolet light. Finally, any moisture contained in the great winds which blow across the poles is deposited to form the great ice caps, so cold that even the carbon dioxide in the atmosphere is frozen out as dry ice.

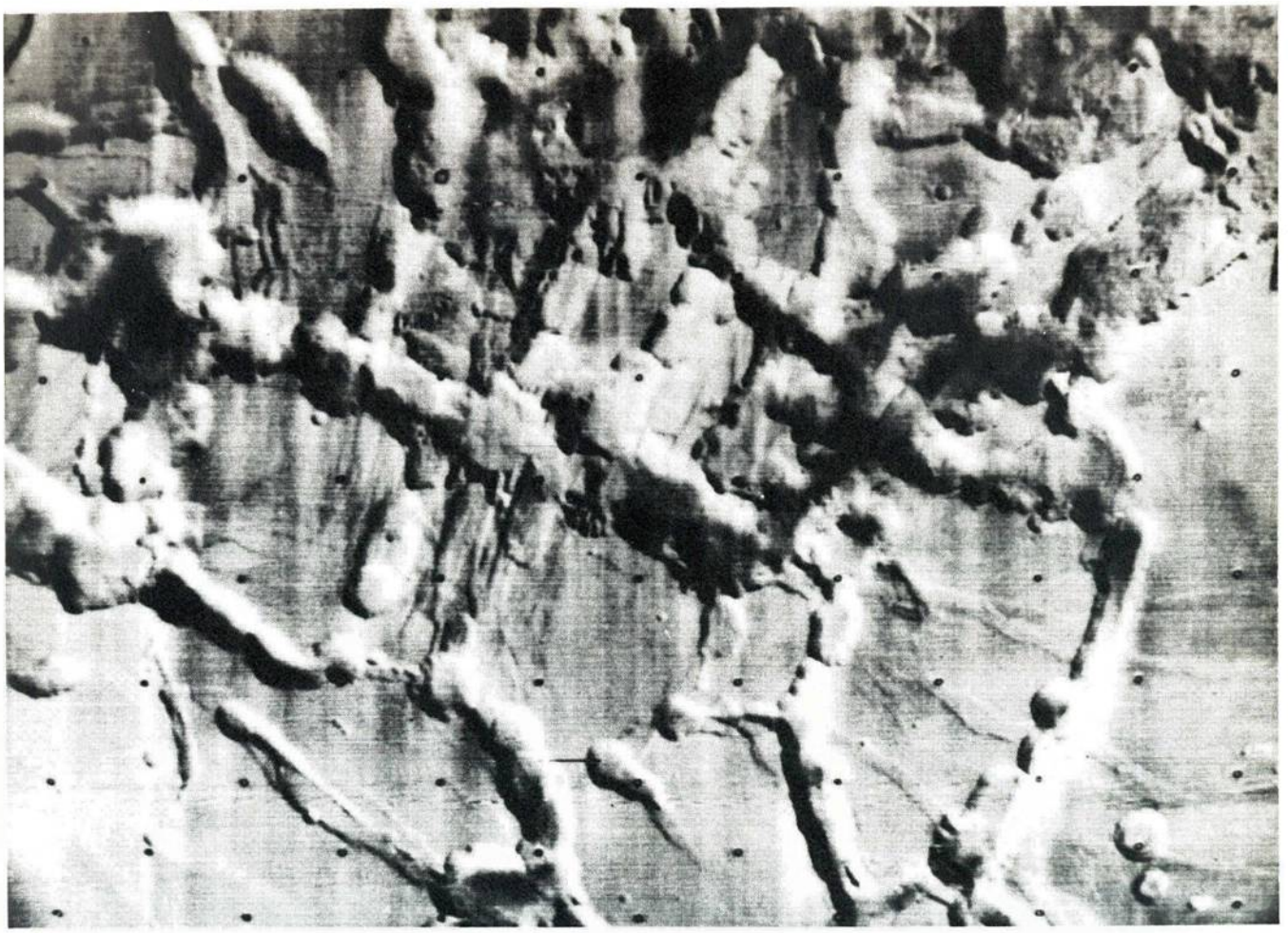
Geologically, Mars is a very rough planet. Its badlands are broken areas of incredible confusion, its rifts deeper and wider than those of Earth, its volcanoes immense. The volcano Nix Olympica has a diameter of 335 miles, towers 15 miles above the surrounding basaltic plain, and has a main caldera (collapsed vent) 40 miles wide. Mariner photographed 19 such volcanoes, all of them huge. These potential dynamos appear to be dormant now because no heat can be detected in their caldera, although something must be going on deep beneath them. Their slopes are covered with ice clouds formed from moisture whose source must be the volcanoes.

There is some disagreement among the experts as to whether volcanic action is increasing or decreasing. One theory holds that Mars is getting hotter below the surface and will produce more volcanism than is now evident. Another speculation, based on lack of heat in the caldera, assumes that the volcanic activity of the great mountains



NASA Photograph

There is a possibility that the small channels shown here were made by water. Channels such as these are widespread on the planet, which indicates that at some time in past history rainfall may have been widespread on Mars.



NASA Photograph

The "Canyon Lands" of Mars are unlike any found on Earth. They look as though they were formed from massive collapse of the Martian crust. The area shown here is huge: 254 x 195 miles.

has passed its peak and is now subsiding. There are other volcanoes on the planet but these are much older than the 19 giants. If the number of surrounding impact craters can be used as a geologic clock, some of these fossil volcanoes may have been formed three billion years ago.

In places the surface has broken up into deep canyons, especially in the area Phoenicis Lacus (Lake of the Phoenix). The canyons run in every direction for hundreds of miles. East of this area lies the greatest canyon of all, the Ciprates chasm, 20 thousand feet deep. This great trench is so wide in places an observer standing on one rim could hardly see the opposite one, 150 miles away.

Not all of Mars is rough, however. Across vast expanses of the northern hemisphere lie the great basaltic plains, geologically very old and therefore pockmarked with many craters. Because of their great age some of these craters have filled with sand and dust in the form of dunes. In fact, dust lies over every feature of Mars, high or low. It is in almost constant motion from the winds which blow across the face of the planet, usually of local origin but occasionally of global dimensions. The thin air must move with great speed to keep the dust moving and this is just what happens — in places winds may blow with a velocity of 300 miles per hour.

In the end, as far as forms of life are concerned, Mars turns out to be an inhospitable planet, almost as hostile as the moon. Its temperature extremes are great, ranging from -190 degrees Fahrenheit at the poles to a possible 80 degrees at noon on the equator. Its thin air contains practically no oxygen or water vapor. A deficiency of ozone in the upper atmosphere exposes the surface to deadly ultraviolet radiation. On the surface are badlands worse than any desert, riverbeds which may not have contained water for millions of years, barren plateaus, rifts four miles deep, supervolcanoes, and everywhere the blowing, shifting dust.

SKY ALMANAC

by

Terence Dickinson

With Jupiter in excellent position for evening viewing and Mars drawing nearer to Earth, the small telescope user finds plenty to watch in September skies.

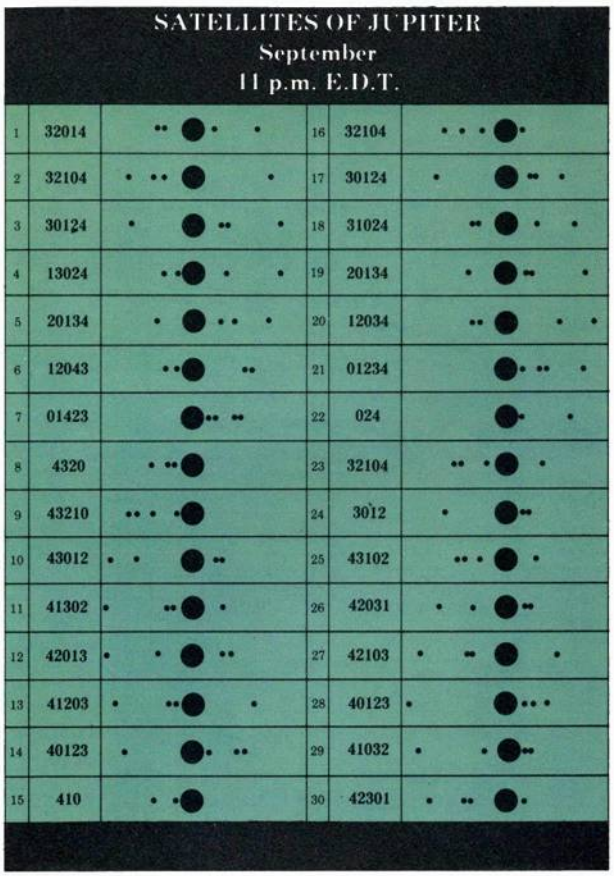
Jupiter

Two months ago a woman called the Strasenburgh Planetarium to report a UFO (Unidentified Flying Object) that was hovering outside her kitchen window. She described it as "a bright light that I had never seen before. I watched it for about half an hour and then it disappeared," she continued in an obviously sincere tone.

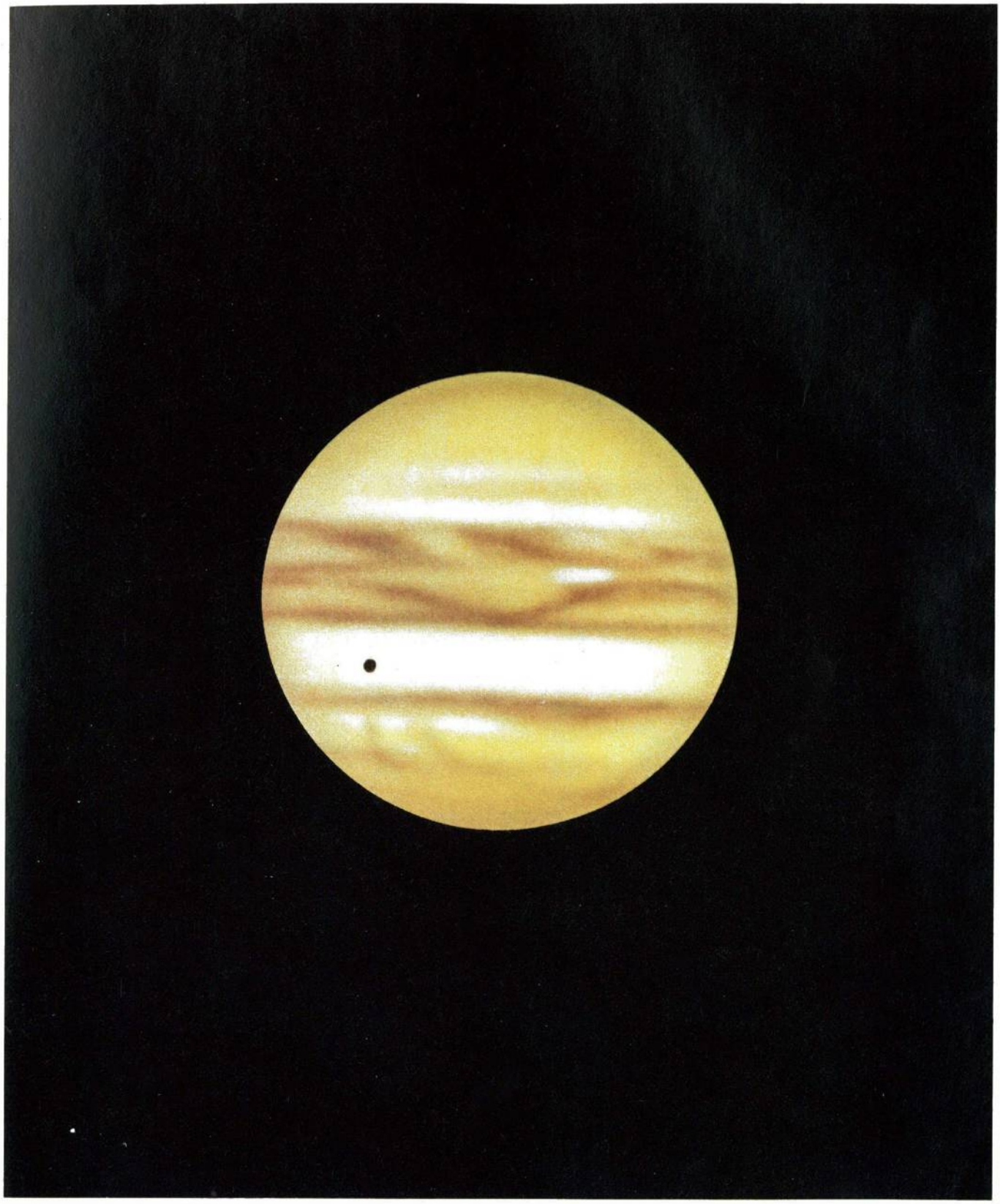
After further questioning we learned that she was up an hour later than her usual bedtime and that she "never looked at the sky very much". The kitchen window faced southeast so there was no question that the "light" was the planet Jupiter which was hidden by a cloud after a half hour of visibility. It was new to her because normally she would be looking out the window earlier in the evening before Jupiter got above the trees. Wind in those same trees probably gave the illusion of hovering.

This anecdote is not an isolated case. At magnitude -2.2 Jupiter outshines the brightest stars in its immediate surroundings by over 100 times, so this year in particular it may startle those who "never look at the sky very much". For those of us that do look skyward, the dazzling yellow-white point of light in the south these September evenings is first choice on the observing roster.

The drawing on the next page is an artist's copy of a sketch of Jupiter. The type of detail shown in the illustration can be seen by an experienced planetary observer using a three inch refractor under good seeing conditions.



The positions of Jupiter's four brightest moons change hourly and daily, and make an interesting sight to view even in a small telescope or high powered binoculars. Shown above is the approximate appearance of Jupiter and its satellites as they might look in a small telescope at 11 p.m., EDT. First column on the left shows the date. Second column of numbers identifies the moons and their position relative to Jupiter's disk. (1 Io; 1 Europa; 3 Ganymede; 4 Callisto, and 0 Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions.



The appearance of Jupiter in a three inch refractor at 100 power as seen by the author, an experienced planetary observer. The equatorial region was described as "extremely complex and full of detail" in the notes made at the time of observation (9:50 p.m. EDT October 12, 1962). The seeing was slightly better than average and the shadow of the Jovian moon Europa was very distinct on the south tropical zone, a region Dickinson noted was the brightest part of the planet that night. This color rendering is artist Victor Costanzo's copy of Dickinson's original pencil sketch.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EDT)	Transit ends (EDT)
Sept. 1	1	1:26 a.m.	2:44 a.m.
1	3	in progress	10:26 p.m.
1-2	2	9:23 p.m.	12:12 a.m.
2	1	7:54 p.m.	10:12 p.m.
8	1	3:21 a.m.	5:39 a.m.
8	4	in progress	11:19 p.m.
8-9	3	10:50 p.m.	2:26 a.m.
8-9	2	11:58 p.m.	2:48 a.m.
9-10	1	9:50 p.m.	12:08 a.m.
16	2	2:34 a.m.	5:23 a.m.
16-17	1	11:45 p.m.	2:03 a.m.
18	1	in progress	8:32 p.m.
24	1	1:41 a.m.	3:59 a.m.
25	1	8:10 p.m.	10:28 p.m.
26	2	in progress	9:16 p.m.
Oct. 2-3	1	10:06 p.m.	12:23 a.m.
3	2	9:02 p.m.	11:51 p.m.

1 = Io
2 = Europa
3 = Ganymede
4 = Callisto

"Seeing" is an expression of the turbulence of Earth's atmosphere as seen in a telescope. Most amateurs use a scale of 1 to 10 to record seeing conditions at the time of observation. It's largely subjective; each observer develops his own estimate based on 10 being perfect (no ripples or any sign of turbulence even at 50 magnifications per inch) down to one being hopeless (no detail at any power due to excessive atmospheric disturbances).

Depending on your location, class 10 seeing is a once or twice a year condition. Unfortunately the low part of the scale is more common than we would like.

But even under average seeing conditions the belts and zones of the giant planet are a continuing fascination. Actually, the features seen on Jupiter are clouds on the top layer of the planet's atmosphere which act, according to recent studies, like the weather patterns over the equatorial areas of Earth. Occasionally small dark or light spots appear or disappear from view in a matter of hours. In addition, the 10 hour rotation is constantly bringing new areas into view.

The drawing also shows the shadow of a jovian moon being cast on the south tropical zone of Jupiter. The satellite itself, being lighter in color, is not as easily seen in smaller telescopes.

The illustration at right greatly exaggerates what happens when Jupiter's largest Gallilean satellites eclipse each other. Grayish areas indicate the shadows cast into space by Jupiter and its moons. Here Io is being eclipsed as Ganymede's shadow covers this innermost satellite, while the most distant of Jupiter's largest moons, Callisto, eclipses Europa. To an observer on earth viewing this action through a telescope, Io and Europa would seem to gradually dim from view as Ganymede and Callisto block away the sun's light.

CALLISTO
GANYMEDE
EUROPA
IO

SUN

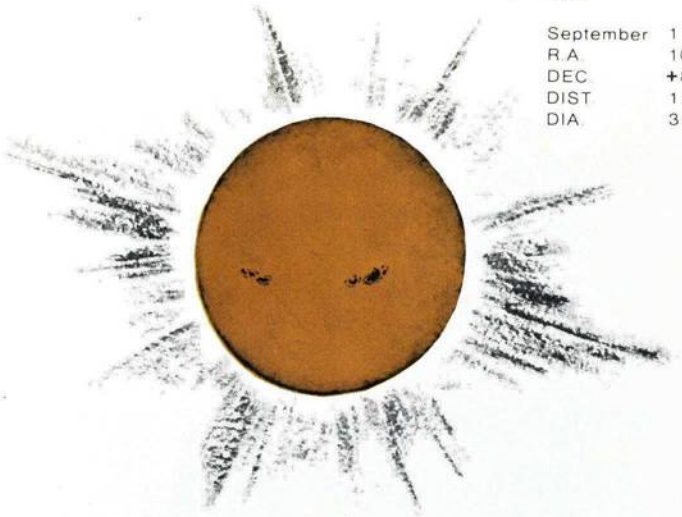
September	1	15
R.A.	10^h40^m	11^h31^m
DEC.	+8°25′	+3°10′
DIST.	1.009 A.U.	1.006 A.U.
DIA.	31′	31′

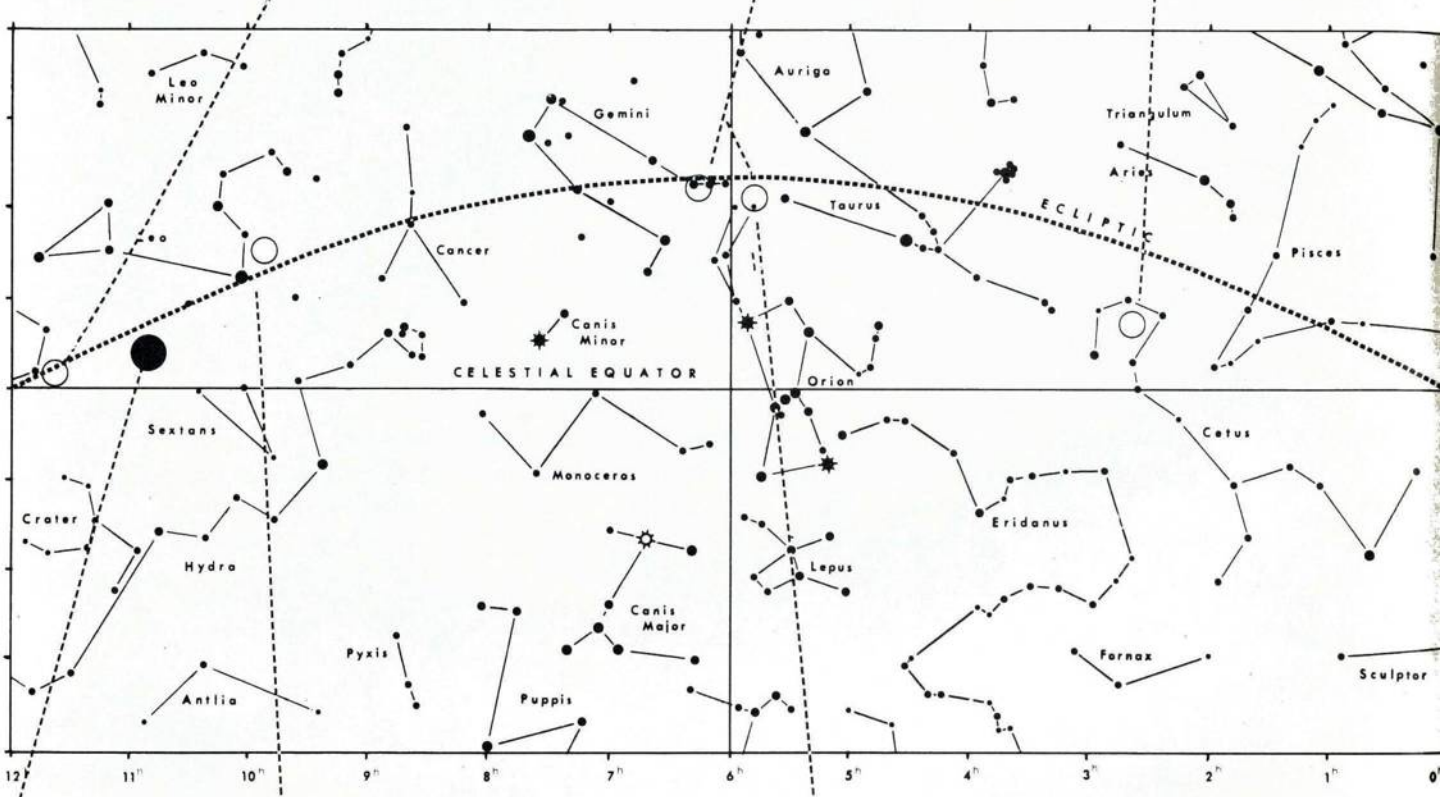
SATURN

September	1	15
R.A.	6^h12^m	6^h16^m
DEC.	+22°21′	+22°19′
DIST.	9.387 A.U.	9.168 A.U.
DIA.	15.88″	16.26″
MAG.	+0.3	+0.3

MARS

September	1	15
R.A.	2^h28^m	2^h31^m
DEC.	+10°27′	+11°17′
DIST.	0.565 A.U.	0.506 A.U.
DIA.	16.5″	18.5″
MAG.	-1.3	-1.6





NEW MOON

August 28

R.A.	10^h19^m
DEC.	+5°51′

VESTA

September	1	15
R.A.	9^h32^m	9^h58^m
DEC.	+17°14′	+15°27′
DIST.	3.390 A.U.	3.309 A.U.
DIA.	——	——
MAG.	+8.8	+8.8

THIRD QUARTER

September 19

R.A.	5^h44^m
DEC.	+24°03′

This planet finder chart shows the positions of the sun, moon, planets and brighter asteroids for the current month as they appear against the background of the zodiac. Positions are plotted for the 15th with additional ephemerides for the 1st. To find zodiacal constellations visible during the current month, see Star Dome.

FULL MOON

September 12

R A	23^h14^m
DEC	+0°20

JUNO

September	1	15
R A	16^h36^m	16^h45^m
DEC	-8°16	-9°30
DIST	3 029 A U	3 203 A U
DIA		
MAG	+11 2	+11 4

NEPTUNE

September	1	15
R A	16^h12^m	16^h13^m
DEC	-19°31	-19°33
DIST	30 358 A U	30 590 A U
DIA	2 40	2 40
MAG	+7 7	+7 7

PALLAS

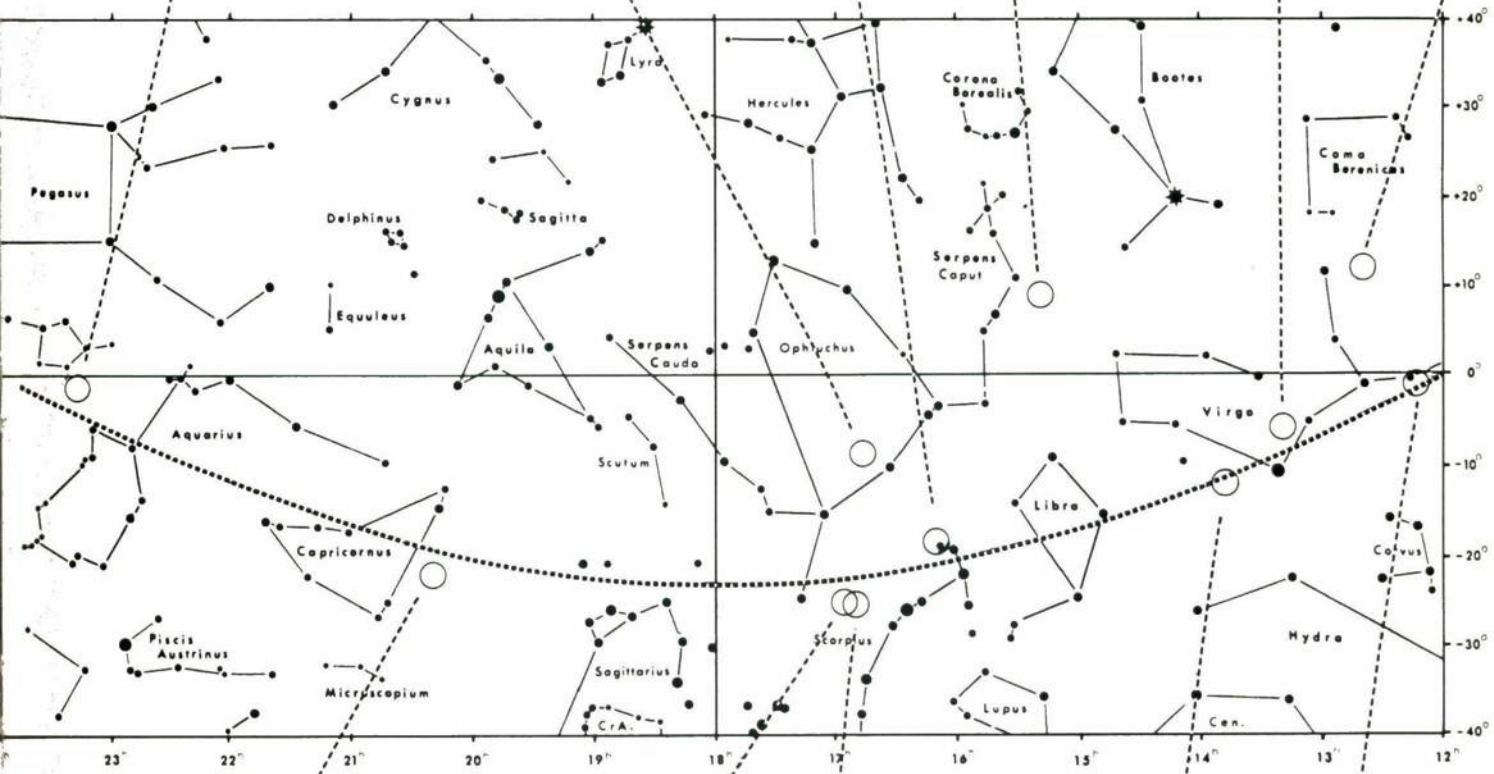
September	1	15
R A	15^h16^m	15^h31^m
DEC	+13°45	+11°36
DIST	3 241 A U	3 406 A U
DIA		
MAG	+9 9	+10 1

URANUS

September	1	15
R A	13^h17^m	13^h20^m
DEC	-7°34	-7°51
DIST	19 144 A U	19 280 A U
DIA	3 58	3 56
MAG	+5 7	+5 7

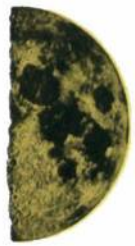
PLUTO

September	1	15
R A	12^h37^m	12^h38^m
DEC	+13°33	+13°19
DIST	31 912 A U	31 962
DIA		
MAG	+14	+14



JUPITER

September	1	15
R A	20^h24^m	20^h20^m
DEC	-20°08	-20°20
DIST	4 222 A U	4 366 A U
DIA	43 52	42 10
MAG	-2 3	-2 2



FIRST QUARTER

September 4

R A	16^h40^m
DEC	-24°13

CERES

September	1	15
R A	16^h25^m	16^h38^m
DEC	-23°22	-24°14
DIST	2 669 A U	2 867 A U
DIA		
MAG	+8 4	+8 6

VENUS

September	1	15
R A	12^h57^m	13^h58^m
DEC	-5°56	-12°47
DIST	1 204 A U	1 107 A U
DIA	13 9	15 2
MAG	-3 5	-3 6

MERCURY

September	1	15
R A	10^h36^m	12^h10^m
DEC	+10°43	-0°11
DIST	1 357 A U	1 377 A
DIA	5	5
MAG	-1 5	-0 7

On the evening of September 1 two shadows will be on the face of Jupiter and on the evening of the 8th three shadows can be seen although not all at the same time (Callisto leaves before Europa gets started).

The rare phenomonon of one satellite's shadow eclipsing another satellite occurs three times this month. On September 6 at about 9:25 p.m. EDT the shadow of Io (1) covers most of Europa (2). On September 16 at about 10:45 p.m. EDT Ganymede's (3) shadow will nearly totally cover Europa. And on the 24th at 3:05 a.m. EDT the same event takes place except that Europa should be totally eclipsed. Each of these events lasts from 15 minutes to half an hour so be sure to allow enough "lead time" so you can watch the fading and possible extinction of the eclipsed moon and its rise back to normal brightness. A 2.4 inch (60mm) refractor will show the event.

During September, Jupiter's distance from Earth increases from 393 to 425 million miles causing its equatorial diameter to diminish from 46 to 43 seconds of arc by month's end.

Mars

Rising in the southeast about two hours after sunset, Mars is now in a good position for amateurs to begin detailed observations. (See additional article in Gazer's Gazette, page 28).

Venus

Continuing to brighten and increase its apparent distance from the sun, the brightest planet is now more noticeable than earlier this year. The brilliant white planet Venus is visible in the southwest for almost two hours after sunset. Its visual magnitude increases from -3.5 to -3.7 during September because its distance decreases from 112 to 93 million miles from earth. Venus is catching up with earth and rendezvous (inferior conjunction) occurs on January 23, 1974.

In the telescope, Venus looks like a featureless gibbous moon. We see 77 percent of the planet sunlit on the 1st of September but by the 30th the phase is reduced to 67 percent. Apparent diameter increases from 14 to 17 seconds of arc during the month. Near the end of September a 2.4 inch refractor should reveal the phase quite plainly.

Saturn

Situated in the constellation Gemini, the ringed planet remains rather inconveniently placed for evening observation. Observers still active after 2:00 a.m. will find Saturn between the constellations Orion and Auriga. The rings are fully inclined to our view about 41 seconds of arc in apparent width. Although a two inch scope will show the rings, wait till later this year for a better view at more convenient hours.

Mercury

The innermost planet is not visible this month because of its apparent nearness to the sun.

Uranus

Although Uranus is never quite visible to the unaided eye there are times when planets or stars appear in the same telescopic field with this faint outer planet. Such an event occurs on September 5 just after sunset when Venus and Uranus will be about 3/4 of a degree apart. Here's what to do:

Select your lowest power eyepiece (the one that you use to view the whole disk of the moon) and train your scope on Venus. Move Venus to the south edge of the field (use your declination slow motion for this if your scope is so equipped) and Uranus should be visible at the opposite side of the field of view. Remember, you have to move the telescope north to get Venus to move south in the field of view. Uranus, at 6th magnitude, is 6,000 times fainter than Venus so the sky must be fairly clear and reasonably dark before it will be obvious. Under such conditions any telescope over two inches aperture should do the job.

In experiments such as this it's always convenient to have a table with the field of view of each of your eyepieces. It's easy to make up such a table. Take each eyepiece in turn and select a star near the celestial equator (Altair is a good choice), or see Star Dome for stars closer to the celestial equator. Now let the star drift across the center of the undriven telescope field. Once you have determined that the star will bisect the field of view, move it just outside so it will drift in. As it drifts across, time the interval from appearance at one side (east) to disappearance at the other (west). This period in seconds, divided by four, is the diameter of your field of view in minutes of arc. (Minutes are indicated ', and seconds ".) Since Venus and Uranus will be 48 minutes of arc apart on September 6, an eyepiece having a field of 50 minutes of arc or greater will be required to see them both at once. A tabulation of eyepiece field diameters will be a useful addition to your knowledge of your own telescope. The table will only be good for your scope since the values will change if the same eyepieces are used in another instrument.

X and g Herculis

by

R. Newton Mayall

The constellation Hercules has two variables close together which are easily seen in binoculars. One (g) is a semiregular variable, while the other (X) has a more regular period of variation.

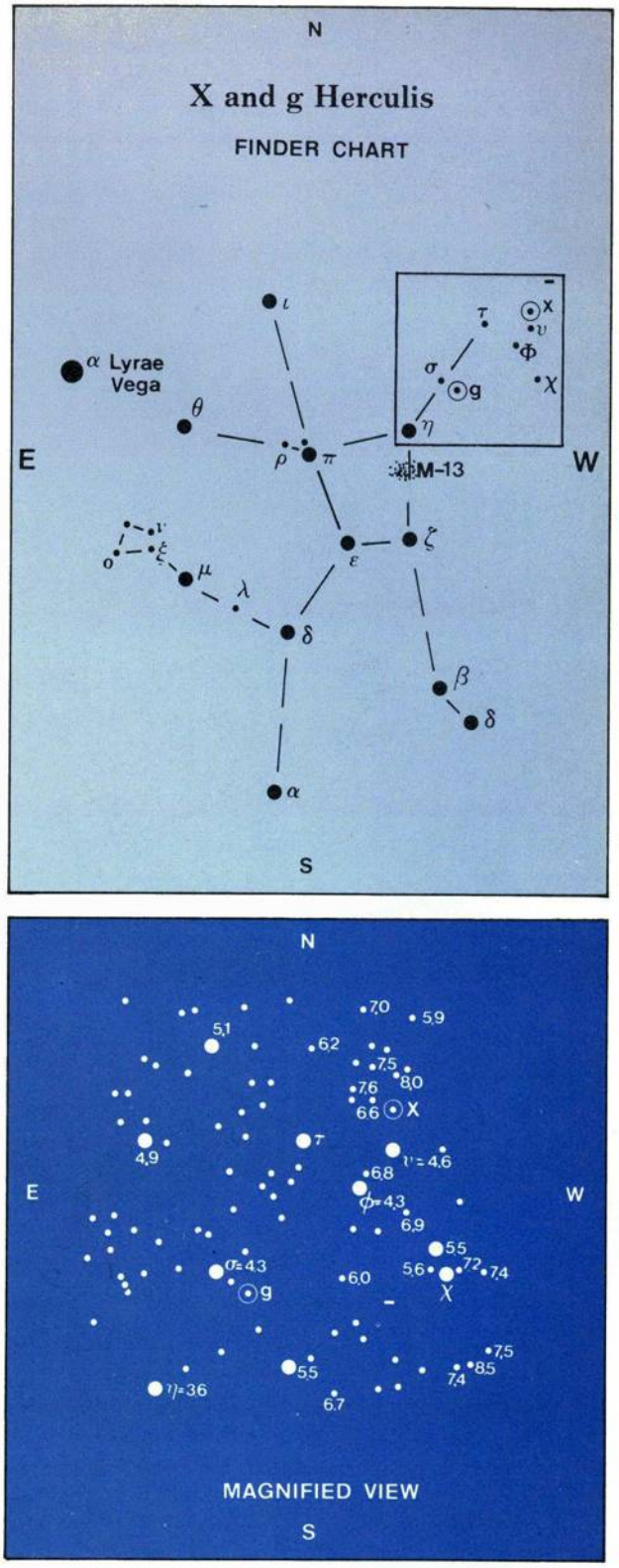
The star "g" was discovered variable in 1857 by Baxendell (1815-1887), a Manchester, England businessman. Baxendell became interested in astronomy and, together with a friend, built an observatory and equipped it with a 13 inch reflector and a five inch refractor. He later moved to Southport where he built another observatory. Here, equipped with a six inch refractor, he devoted himself to the observation of variable stars.

Irregularity or erratic variability is what makes "g" interesting. Although its range in magnitude is generally given as 4.4 to 6.0, actual observations have shown it to be as bright as magnitude 4.0 to a little fainter than 6.0. Semiregular variables are those having no persistent period. Variable "g" is easily located southwest of Sigma Herculis.

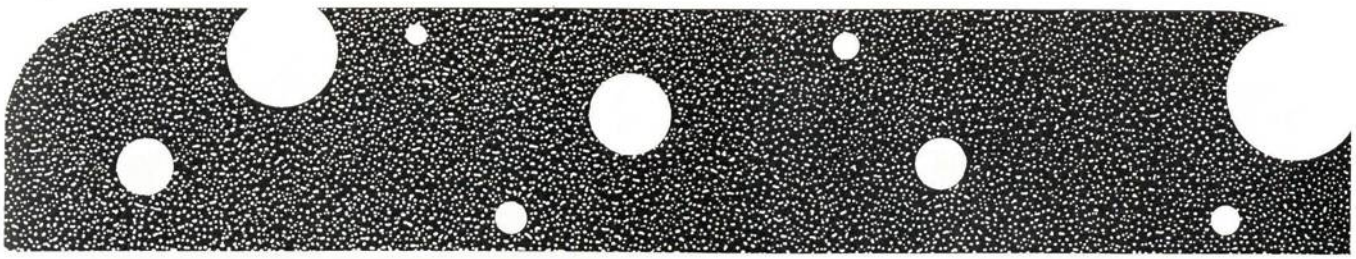
X Herculis was discovered by Gore in 1890. It varies in magnitude from 6.3 to 7.4 with a period of 100 days. It is located about one degree due north of Upsilon which forms a small triangle with Phi and Tau Herculis.

Those who observe these stars with binoculars will probably find them both in the same field. This will be an advantage. If this month's charts are used with a telescope they must be inverted.

Why not stop a minute on your way to "X" and "g" and observe one of the most beautiful clusters in the sky — M-13. It is marked on the finder chart about a third of the way from Eta to Zeta Herculis. It is about magnitude 6.0 and faintly visible to the unaided eye. In a small telescope it appears as a large, bright nebulous object, but in a larger telescope it is a spectacular globe of sparkling stars.



The above pair of charts show "right side up" views of the constellation Hercules. The upper chart shows the entire constellation as it appears in the night sky. X and g Herculis are located in the box which is shown magnified in the lower map. Numbers to the right of stars surrounding the variables in the magnified view are magnitudes for background comparison stars.



Which Came First: The Galaxy or the Quasar?

by

Wm. Bruce Weaver

Since discovery of the first quasi-stellar radio source in 1960, quasi-stellar objects (QSOs) have captured the attention of professional and amateur astronomers, and the general public as well. QSOs, also called quasars, may be one of the strangest constituents of the universe — they are certainly among the least understood at this time. As the name implies, they look like stars, but act more like galaxies. Now it appears that QSOs may give "birth" to galaxies or vice versa.

One of the most powerful instruments available to astronomers is the spectrograph. All objects in the universe either emit or reflect light. The spectrograph analyzes light coming from a celestial object by breaking up its "white" light into a rainbow of colors called a spectrum. (Raindrops act as prisms in Earth's atmosphere, breaking up sunlight into its component colors, creating a rainbow.)

From this spectrum of colors astronomers can tell the temperature, chemical composition and radial velocity (speed toward or away from Earth) of very distant objects. Elements and molecules in celestial objects absorb some of their own light causing dark lines to appear across the spectrum at certain colors. The faster an object is moving away from the observer, the more these dark lines are shifted toward the redder parts of the spectrum. If the object were approaching, these lines would be shifted toward the spectrum's blue end.

More tersely stated, this is called the redshift, and it is to light what the Doppler effect is to sound.

The dark lines or absorption lines in the spectra of quasi-stellar objects have been shifted so far toward the red that it was not until three years after QSOs were discovered that Maarten Schmidt, an astronomer at Palomar Observatory, was able to identify the first of the elements responsible. It turned out to be hydrogen, the most common element in the universe!

In the early 1930's, astronomers M.L. Humason and E. Hubble established that the farther a galaxy was from Earth, the more the lines in its spectrum were redshifted. The most distant galaxies observed have the largest redshifts, indicating they are receding from us at 41 percent the speed of light. The redshifts of QSOs are so great that they seem to be receding from us at speeds greater than 80 percent the speed of light, faster than any celestial object ever measured. Hence, astronomers reasoned that they must be the most distant objects that we can observe in the universe! This was very exciting, because QSOs might tell us something about the birth of the universe.

Currently, the most popular theory about the birth of the universe suggests that in the distant past all matter was situated in one place. This primordial ball of matter exploded and expanded outward, providing the matter for the planets, stars and galaxies of the universe as we know it today. According to this cosmological hypothesis, called the "Big Bang" theory, the most distant

No one knows what a quasar might look like from a distance of only a few thousand light-years, but artist Victor Costanzo of the Strasenburgh Planetarium, Rochester, N.Y., produced this rendering for a recent planetarium show. Costanzo visualizes the incredible energy output of quasars — equal to trillions of suns — flooding in all directions from a nearly point source. The origin of this prodigious radiation is astronomy's most baffling enigma. Recent investigations seem to indicate that quasars may be an evolutionary stage in the development of galaxies.

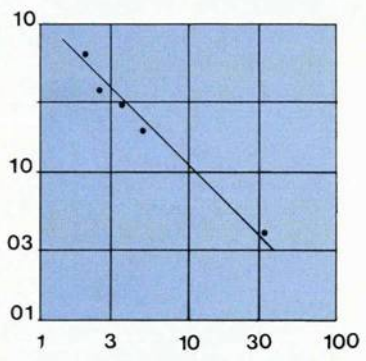
objects should be receding from us at almost the speed of light.

If QSOs are at the edge of the observable universe, as the theory implies, then they are so far away that the light they emit takes an appreciable fraction of the age of the universe to reach us. That is, by looking at the "fossil" light from QSOs, astronomers would be looking back to a time when the universe was much younger than it is today, and perhaps much different.

Nature almost never lets her secrets be so easily explained. Some QSOs have now been observed with more than one redshift. Some have as many as five different redshifts, implying that they are receding at five greatly different rates. Clearly, this is not physically possible. One explanation is that QSOs are ejecting matter at very high velocities. As the ejected matter passes between the QSO and Earth, it would produce a different redshift in the spectrum of the QSO.

Not all astronomers subscribed to the cosmological explanation of QSOs. In 1967, H.C. Arp suggested that QSOs were ejected at high speeds from certain types of peculiar galaxies. This was not a very popular theory at that time because it could not explain why as many QSOs were not observed rushing toward us as away from us. Even though Arp and others published photographs showing quasi-stellar objects which were quite close to galaxies, many astronomers dismissed this as coincidence.

Recently, however, three astronomers, G.R. Burbidge, S.L. O'Dell and P.A. Strittmatter, compared the positions of QSOs with bright galaxies. Five were found to be within seven minutes of arc of each other. The probability of this apparent association of five QSO/galaxy pairs at such an angular separation occurring by chance is roughly 1 in 100,000. What's more, the five galaxies exhibit



The physical separation of five quasi-stellar object/galaxy pairs was plotted against the redshift of the galaxy. The slope of the line indicates that there is a constant, physical separation between the QSO and galaxy which corresponds to about 40 thousand light-years. If this constant separation is coincidental, its chance of occurring is 1 in 100,000.

fairly normal rates of recession, while their associated QSOs have the usual, much larger redshift values. If these five pairs are indeed physically associated, then the enormous QSO redshifts are not due to tremendous distances.

Perhaps the most amazing result of this investigation was obtained by Burbidge and his associates when they plotted the angular separation of the pairs against distance to the galaxy. As shown in the diagram, the greater the galaxy redshift (that is, the farther the galaxy is from the earth) the smaller the separation of the galaxy/QSO pair. In fact, the slope of the line drawn through the plotted points indicates a constant physical separation between the galaxies and the QSOs! The exact separation is hard to determine but seems to be somewhere around 40 thousand light-years.

The simplest explanation is that the QSOs are moving in gravitationally bound orbits around their related galaxies. At these distances, the QSOs are most likely less massive than the galaxies. Therefore, if one gives rise to the other it is most probable that the galaxy gives "birth" to the QSO.

Other quasi-stellar objects, which do not seem to be related to galaxies, may have escaped during a near collision between two galaxies. Or perhaps they were ejected from their parent galaxies at a velocity too high to remain gravitationally bound and escaped into intergalactic space.

Separately, J. Kristian of Hale Observatories has found some QSOs which appear to be embedded in the center of galaxies. Perhaps these are QSOs just being "born". Or perhaps certain types of galaxies go through a stage during which the nucleus becomes extremely bright. The rest of the light from the galaxy appears so dim by comparison that all we can see is a quasi-stellar object.

While these developments cast serious doubts on the cosmological origin of the large redshifts observed in QSOs, they do not offer a substitute explanation.

The evidence is becoming more and more convincing that there is some physical relationship between galaxies and QSOs. If this is true, QSOs will probably not be the key to understanding the youth of our universe. Instead, they should open up whole new concepts in the evolution of galaxies. There are bound to be many more surprises in the next few years as astronomers continue to try to understand QSOs. And this recent research may very possibly become the key which unlocks one of astronomy's most enigmatic mysteries: the quasar.

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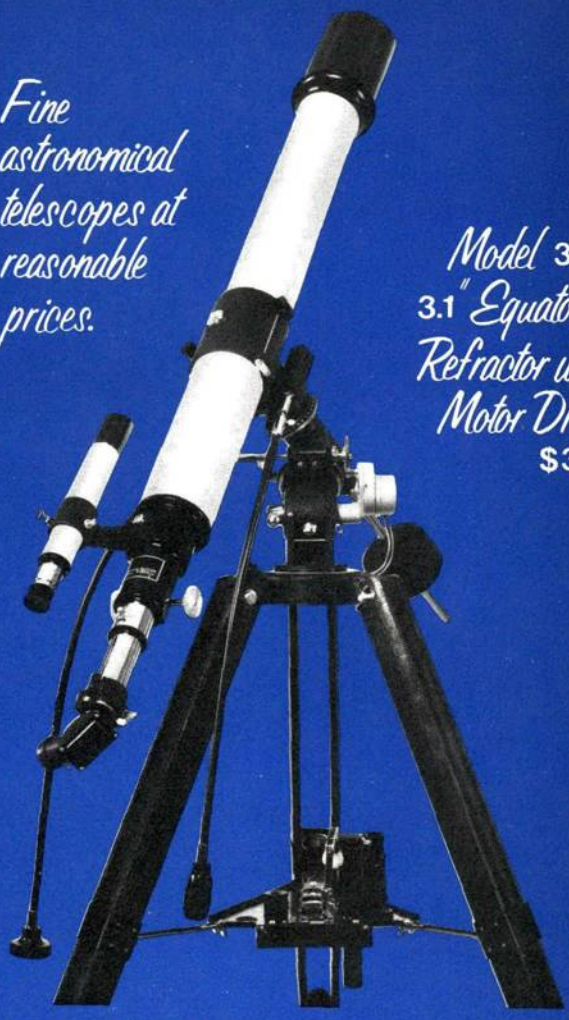

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SEPTEMBER

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet

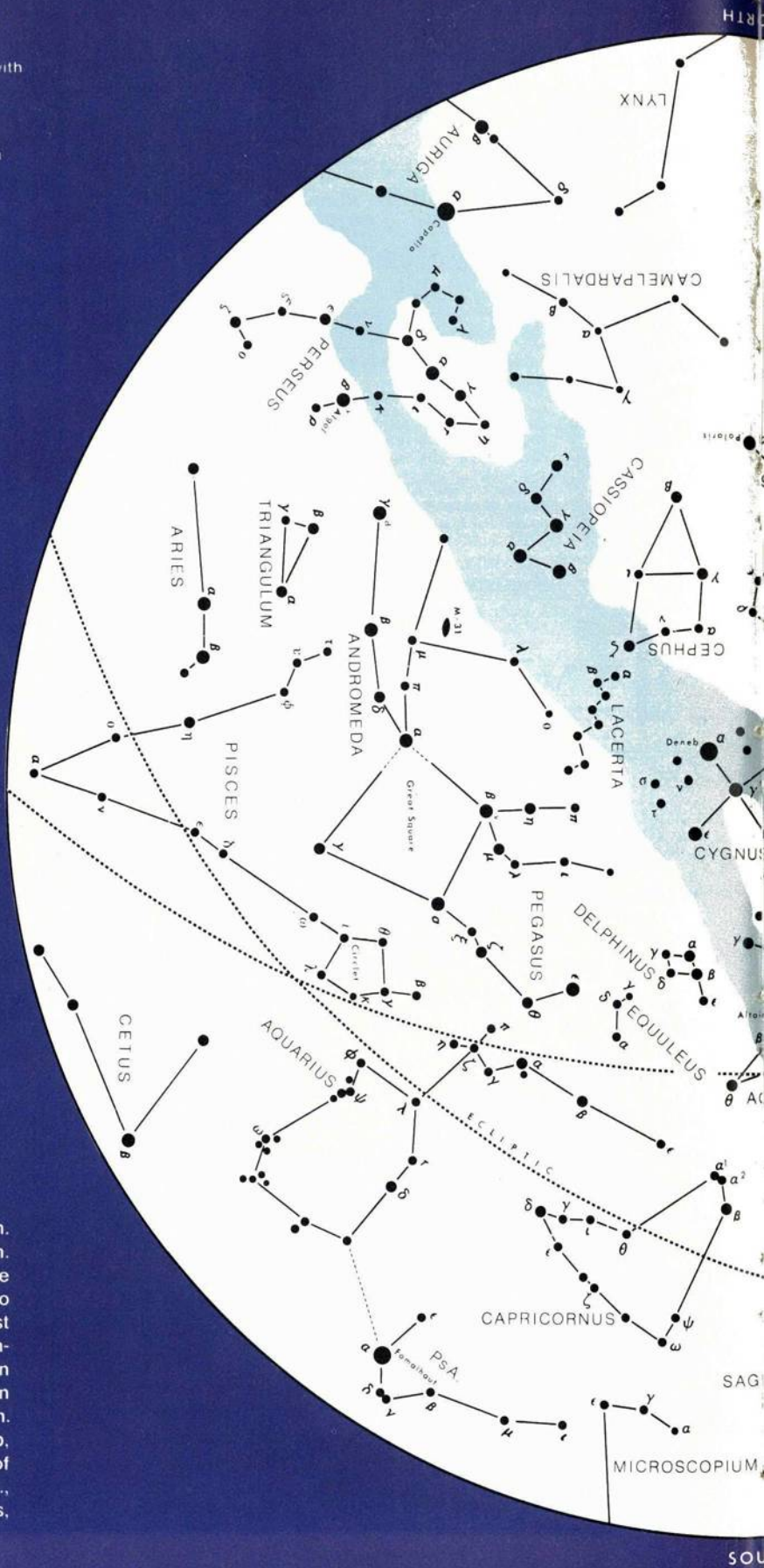
α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars



Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME

by

John G. Harmon

Although autumn begins this month, the stars of the Summer Triangle are still very prominent in our evening sky. The Triangle, of course, is formed by the stars Vega, Deneb, and Altair, the brightest stars in the constellations Lyra, Cygnus, and Aquila. In the same area of the sky, but often overlooked, are a number of smaller constellations.

One of these minor star groups is Vulpecula, the fox. Vulpecula is a faint constellation whose stars are less than fourth magnitude in bright-

ness. The group lies near the star Albireo (Beta Cygni) on a line between Deneb and Altair. The only notable thing about Vulpecula is that the constellation contains Messier 27, the famous "Dumbbell Nebula". On early star maps the constellation was known as "Vulpecula et Anser", the fox and the goose.

Below Vulpecula, on a line between Albireo and Altair, lies the constellation Sagitta, the arrow. Most sources agree that this group represents an arrow, but disagree as to whose arrow it is. Some say it is the arrow with which Apollo slew the Cyclops, while others see it as Cupid's arrow or one of the archer Sagittarius' arrows gone astray. The most plausible story, however, claims that Sagitta is the arrow used by Hercules to shoot the Stymphalian Birds, one of his 12 labors. Sagitta lines up well with Hercules which is only 30 degrees to the west in the sky. Also, Sagitta lies in the middle of the Summer Triangle which to some represents the Stymphalian Birds, two eagles and a swan. In this context Lyra is sometimes seen as the "Swooping Eagle".

Following the Summer Triangle across the sky is the constellation Delphinus the dolphin. In the various legends that surround Delphinus, the dolphin is usually placed in the sky as a reward for a good deed. Here again, as with Sagitta, there is some disagreement as to what that good deed may have been. One legend says that the dolphin aided Neptune in winning the hand of the goddess Amphitrite, who had vowed never to be married.

A second legend says that the dolphin saved the life of Arion, a wealthy and talented musician. Once, when on a voyage back to his homeland, the sailors aboard his ship decided to kill him for his money. Arion begged his would-be slayers to allow him to play a final song on his lute. The request was granted and Arion began to play. The music attracted a school of dolphins. Seeing them, Arion jumped into the water and one of the dolphins carried him to safety.

A third good deed attributed to Delphinus is the recovery of the body of the poet Hesiod after it had been cast into the sea by his murderers.

A common name for Delphinus is "Job's Coffin". While the origin of this name is not clear, by stretching your imagination the shape of the constellation might resemble an old fashioned coffin.

Three stars in this constellation — Alpha, Beta and Epsilon Delphini — have names. Alpha and Beta are called Sualocin and Rotanev respectively, and their meanings remained a mystery for many years. It seems that an industrious assistant to the astronomer Piazzi arbitrarily decided to immortalize himself among the stars by reversing the spelling of his name, Nicolaus Venator. Epsilon is known as Deneb, Arabic for "the tail", an example of how more than one star can have the same name. For reasons solely apparent to the oriental mind, the Chinese called this star "The Rotten Melon".

Still farther to the south along the Milky Way is the zodiacal constellation Sagittarius, the archer. The archer is generally pictured as being a centaur (half man, half horse) and mythologically it is sometimes confused with the southern constellation Centaurus. Sagittarius depicts Chiron, the son of Philyra and Saturn. It is said that Chiron changed himself into a horse to avoid his jealous wife Rhea. Chiron was known for his ability as an archer and is usually pictured with a bow and arrow — the arrow aimed at the heart of Scorpio, the scorpion. Sagittarius is also known as the "bull slayer", a name which originates from the fact that the constellation Taurus sets as Sagittarius rises.

An asterism called "The Milk Dipper" is formed by the stars Zeta, Tau, Sigma, Phi, and Lambda Sagittarii. It is so named because it appears to be dipping milk out of the Milky Way.

Following the archer across the September skies is the constellation Capricornus, the sea goat. Old star maps picture Capricornus as a strange creature that had the head of a goat and the tail of a fish. This image is extremely ancient, going back to the time of the Babylonians who pictured it on their boundary stones.

The figure of the sea goat seems to be symbolic. In ancient times the winter solstice took place in this constellation and the goat represents the sun climbing back up into the sky, while the fish's tail symbolizes the rains and floods the season brings.

Of all the legends concerning Capricornus, perhaps the most interesting dates back over 5,000 years to the books of Sargon, the founder of the Semitic empire. The legend states that when all the planets are in conjunction in this constellation, the world will end in a conflagration. The closest we've come to this disaster was in 2449 B.C. when Chinese astronomers witnessed a conjunction of five planets in this constellation.

Capricornus has found its place in the history of astronomy: on September 23, 1846 near Delta Capricorni, the planet Neptune was found and first identified by astronomer J. G. Galle.

AUTHORS

Terence Dickinson — Mr. Dickson has joined the staff of ASTRONOMY as eastern regional editor. In addition he will contribute monthly articles to Sky Almanac.

Mr. Dickinson is Assistant Director of the Strasenburgh Planetarium, Rochester, N.Y., and Science Editor of the Rochester Museum and Science Centre. There, his efforts are devoted to research and preparation for audio-visual astronomy programs. He was previously on the staff of the McLaughlin Planetarium at the University of Toronto in Canada.

Born in Canada, Mr. Dickinson first became interested in astronomy at the age of nine when his father took him to visit the Dunlap Observatory near Toronto. His knowledge broadened and at age 17, he presented the first of a long series of lectures to the Royal Astronomical Society of Canada.

Mr. Dickinson has been a consultant for space science programming for the Canadian Broadcasting Corporation and Canadian Television Network. His recent book, **Exploring the Moon and the Solar System**, is used in Canadian schools. His scientific articles have also appeared in numerous magazines, journals and newspapers.

Mr. Dickinson is a life member of the Royal Astronomical Society of Canada and a member of the British Interplanetary Society, the American Institute of Aeronautics and Astronautics, and the Rochester Academy of Science.

Stephen A. Walther — Mr. Walther is the president of AstroMedia Corporation and publisher of ASTRONOMY magazine.

A 1971 graduate of the University of Wisconsin — Stevens Point, Mr. Walther was previously employed in public relations by Cutler-Hammer, Inc. and Scannell, Inc., both in Milwaukee, Wisc. While a student at the University of Wisconsin, he worked part time as a planetarium lecturer.

Mr. Walther has been active in astronomy for 16 years. Ten years ago he developed a specialized method of astrophotography, and has since been published in several astronomy magazines and books. He also regularly gives public lectures on astronomy throughout southeastern Wisconsin.

John R. Sanford — Mr. Sanford is an assistant professor in the photography department at Orange Coast College in Costa Mesa, Calif.

After graduating in 1961 with a degree in anthropology from Cornell University, he entered the Army. While in the service he was trained in photography and photo lab operations, and was a member of the first photo team to go to Vietnam in 1962. Subsequent to his discharge, Mr. Sanford worked for I.B.M. doing photographic and motion picture work, returned to Vietnam as a civilian tech-rep for a mobile photo lab company, and later worked for Lockheed Missile and Space Company. He eventually returned to school and received an M.A. in Creative Arts Interdisciplinary Studies in 1970.

Mr. Sanford's childhood interest in astronomy was rekindled in 1969 at the opposition of Mars. Pursuant to that interest he joined the Orange County Amateur Astronomers Association, and served as vice president in 1971 and president in 1972.

Neale E. Howard — Mr. Howard is Associate Headmaster at Millbrook School, Millbrook, N.Y.

A native of Maine, Mr. Howard attended Bowdoin College, received a Masters degree from Stanford University and subsequently did graduate work at the Massachusetts Institute of Technology and the University of Pennsylvania. He became interested in astronomy through amateur telescope making and has been teaching in the field for over 30 years.

Mr. Howard is the author of several books, including **Handbook for Observing Satellites, Standard Handbook for Telescope Making,** and **Telescope Handbook and Star Atlas.**

Thomas C. Bretl — Mr. Bretl is a free lance writer and is doing independent work in astronomy, photography and education.

He received a B.A. in mathematics from Haverford College in 1968 and his M.A. degree in the same field in 1969 from Northwestern University.

Mr. Bretl taught math at Morton Junior College in Cicero, Ill. for one year. In 1970 he went to the University Lake School (which he had attended as a child) in Hartland, Wisc. as a physics and math teacher. There, he again became interested in astronomy. In 1971 he ground and polished an eight inch RFT mirror. Later, aided by some of his students, he constructed a 10 inch telescope.

Mr. Bretl is the current president of Starcraft, Inc., a group of astronomy enthusiasts in Oconomowoc, Wisc.

Observing Mars in 1973

by

Terence Dickinson

No celestial object captures the imagination more than Mars. Remember the last time you set up your telescope for some friends (all non-astronomy types, of course) and began demonstrating moon craters and the phase of Venus? They said, "Yeah, that's great, but where's Mars?"

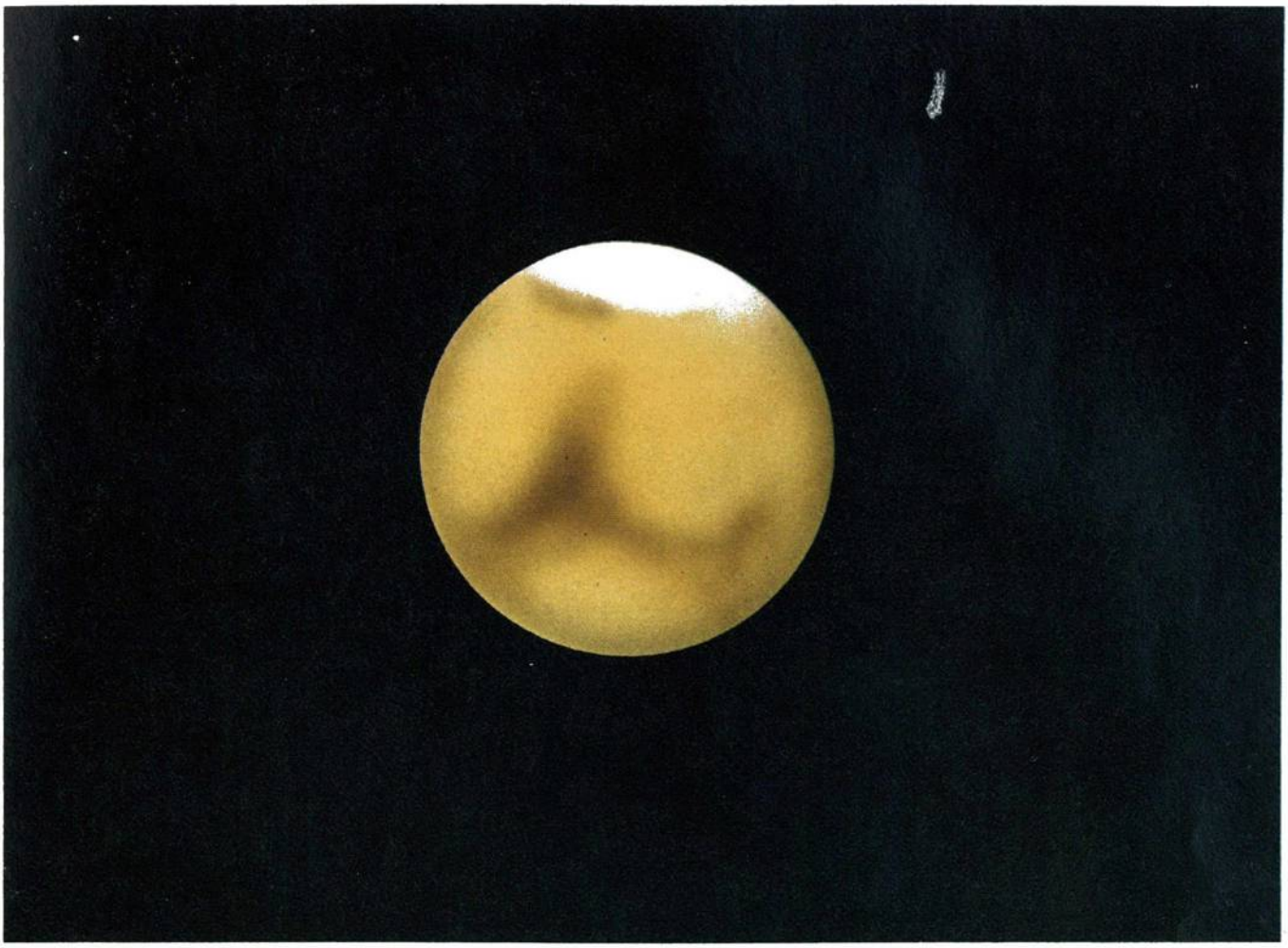
Normally your answer would be, "It's not visible right now," or, "you can't see anything on it anyway." And that's usually the right answer since the red planet is only in good viewing position for about four months every two years.

If you bought your telescope sometime after Christmas, 1971, chances are you have never seen Mars. Or if you have seen it, it looked like a tiny red dot. Because so many observers have so often experienced the "tiny red dot" syndrome, they think there is nothing to see on Mars using, say, a 60mm refractor. This is simply not true.

Before we get down to what you can see, let's find out why Mars is now in excellent observing position.

Every 26 months or so, Earth, having a smaller orbit, catches up to Mars and passes it (much like two stock cars on a circuit where one car stays

Many of the famous "canals" of Mars extend from Mare Erythraeum, the dark region near the center of the globe in this 1971 photo. The south polar region is at the top (as seen in an astronomical telescope). Photo made with the Lunar and Planetary Laboratory's 61 inch telescope shows about the same detail an experienced observer can see in an 8 or 10 inch telescope in good seeing. Compare this photograph with the one made by Steven Reed on page 9.



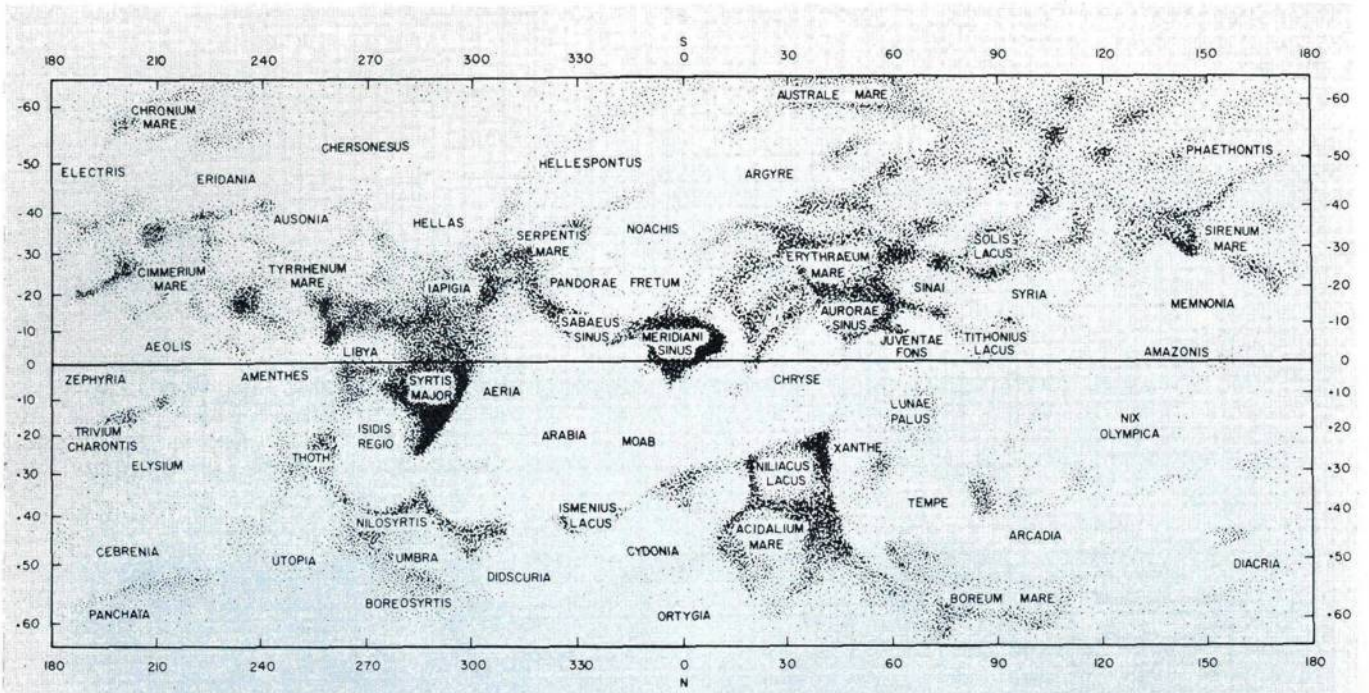
The appearance of the planet Mars in a three inch refractor is shown in this rendering by Victor Costanzo. It is a copy of a pencil sketch made by Terence Dickinson on December 17, 1960 under conditions of excellent seeing. The Martian globe had an apparent diameter of 15 1/2 seconds of arc at that time — significantly less than this year's opposition diameter. Syrtis Major is the large dark region to left of center. The color intensity of the features has been enhanced as is customary in planetary drawings. North is to the top; east is on the right as seen with and eyepiece diagonal.

on the inside and one on the outside of the track). The point of passing or closest approach is called opposition. Because Mars has an elliptical orbit, the distance between the two planets can vary from 35 to 63 million miles from one opposition to another.

The August, 1971 opposition was very favorable — the Earth-Mars distance was at the 34.9 million mile minimum. This year, on October 16, the two planets will be separated by 40.5 million miles. But this year's opposition is actually more favorable — in fact, it is probably the best time for amateurs in the United States and Canada to observe Mars since 1958. How can this be?

Distance is not the only criterion. An equally important factor is the planet's location in the sky. In 1971 it was low in the south in the constellation Capricornus where Jupiter is this year. During the prime observing period in 1971, Mars never was more than 35 degrees above the southern horizon for an observer at latitude 40 degrees north. For that same observer in 1973, Mars will reach 60 degrees altitude around midnight during the next few months. Instead of being hidden in the murk and turbulence that is usually near the horizon, the red planet will be in excellent position for observation. This opposition is almost identical to one in 1958 when amateurs made beautiful maps and sketches of our planetary neighbor.

So what can you expect to see? Probably not much at first glance. The disk of Mars appears about the same size as the planet Saturn (minus the rings) during September, October and November. The surface features are fairly subtle except for major dark areas like Syrtis Major and the white south polar cap. It is now January on Mars — midsummer in the southern hemisphere — consequently the south polar cap is now



(Map courtesy the "Observer's Handbook", Royal Astronomical Society of Canada.)

Most of the features on this map of Mars can be see in a five or six inch telescope. Larger instruments will show more under good seeing conditions. Martian longitudes are listed along the top and bottom of the map and the latitude is indicated on the sides. South is at the top to correspond with the view in a normal astronomical telescope. (Remember that eyepiece diagonals flip the image top to bottom but leave left and right the same.

quite small and should disappear from view in a few weeks.

Here's what to expect in telescopes with apertures from 60mm to 8 inches and larger.

2.4 Inch Refractor

This is the smallest telescope that will show anything at all on Mars. Use about 100 power and, if the seeing is good, the major dark areas shown on the accompanying map should be glimpsed.

3 Inch Refractor or 4 Inch Reflector

After a few nights' observing significant detail should repay your efforts. The drawing on page 29 is a copy of one made in 1960 at a less favorable opposition than this year's. The rotation of the planet becomes obvious after an hour or so.

4 to 6 Inch Telescopes

With these instruments, an experienced amateur can make a detailed map of Mars that will show most of the features on the map of Mars included with this article. Certain dark regions on Mars are known to change size due to violent dust storms and these changes are detectable.

8 Inch and Larger

With a few nights' experience, you should be able to see as much detail as shown on the photographs on these pages. Your own experience and the quality of the seeing are the only limiting factors. Observers with eight inch scopes often say they can see the so-called "canals" — thin lines crossing the desert areas of Mars. This is simply one visual interpretation. That is, some observers see the finest detail as lines; others see patches or streaks.

Notice we keep repeating phrases like "after a few nights" or "with some experience". After the banded multi-colored face of Jupiter, Mars is certainly a disappointment for those unfamiliar with its telescopic appearance. Apart from its rather small apparent size, Mars requires some "getting used to". Each night you observe, you will find yourself seeing more and more — mostly the cumulative effect of experience. You remember how it looked the night before, so you build on that. Added to this is the similarity of rotation periods for Mars and Earth.

Since Mars rotates only 40 minutes slower than Earth, we see almost the same face from one evening to the next. In fact every 24 hours, 40 minutes we see exactly the same region of the planet. Here's an example. The most easily observed dark feature on Mars is Syrtis Major. It

will be nearly at the center of the Martian globe on September 24 at 7:45 p.m. EDT and at 8:25 p.m. on the 25th, 9:05 p.m. on the 26th, and so on. By observing at about the same time each clear evening, a map of the planet, as seen through your telescope, can be compiled in about five weeks.

It's easy to calculate what surface features will be visible at a given time. The accompanying table (see Mars 1973, Below) lists the distance of Mars in millions of miles, the diameter of the planet in seconds of arc (for comparison Saturn averages 18" and Jupiter about 45" in diameter) and finally, the central meridian at 8:00 p.m. EDT. This last column is probably the most useful. It's the one that tells what's visible when. Here's how to use it:

Suppose you are observing Mars at 10:45 p.m. EDT on September 8. The table tells us that the central meridian (C.M.) is 239 degrees on the 7th and 220 degrees on the 9th. This means that these Martian longitudes (see map) are at the center of the disk at 8:00 p.m. on the 8th. But how do we get from 8:00 p.m. to 10:45? Easy: add 15 degrees per hour. Two and three quarter hours multiplied by 15 degrees equals about 41 degrees, so we add 41 degrees to the 8:00 p.m. position of 230 degrees to get 271 degrees for our C.M. longitude for the time we are observing. Reverse the process to find when a particular feature will be on or near the C.M.

MARS 1973

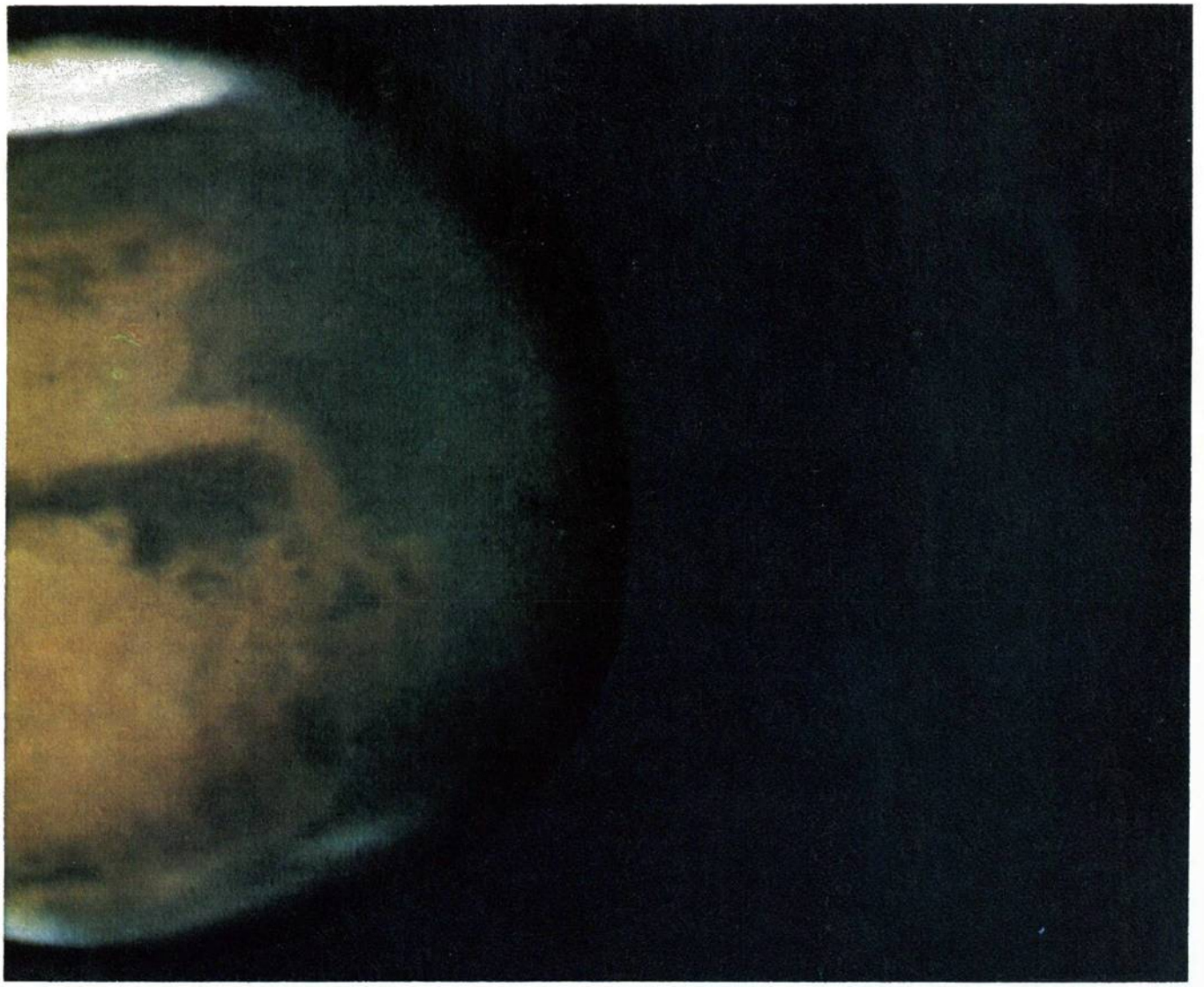
Date	Distance From Earth (Millions)	Diameter (Seconds of Arc)	Central Meridian
Sept. 1	52.1	16.7"	295
3	51.3	17.0	276
5	50.5	17.2	257
7	49.6	17.5	238
9	48.9	17.8	220
11	48.1	18.1	202
13	47.4	18.3	184
15	46.7	18.6	165
17	46.0	18.9	147
19	45.3	19.2	129
21	44.7	19.5	110
23	44.1	19.7	92
25	43.6	20.0	74
27	43.1	20.2	56
29	42.6	20.4	38
Oct. 1	42.1	20.6	20
3	41.8	20.8	3
5	41.4	21.0	345
7	41.2	21.1	327
9	40.0	21.2	309
11	40.8	21.3	292
13	40.6	21.4	274
15	40.5	21.5	256
17	40.5	21.5	238
19	40.6	21.4	221
21	40.7	21.4	203
23	40.9	21.3	186
25	41.2	21.2	168
27	41.5	21.0	151
29	41.8	20.8	133
31	42.3	20.6	115
Nov. 2	42.8	20.3	98
4	43.3	20.0	80
6	44.0	19.8	62
8	44.6	19.5	45
10	45.4	19.2	27
12	46.2	18.9	9
14	47.0	18.4	351
16	47.9	18.1	333
18	48.9	17.8	315
20	50.0	17.4	297
22	50.9	17.0	279
24	52.0	16.7	260
26	53.2	16.3	242
28	54.4	16.0	224
30	55.6	15.7	205
Dec. 2	56.8	15.3	187
4	58.1	15.0	169
6	59.5	14.6	150
8	60.8	14.2	131
10	62.2	13.9	113
12	63.7	13.6	94
14	65.1	13.3	75
16	66.6	13.0	57
20	69.6	12.5	19
25	73.6	11.9	332
31	78.5	11.2	275

During the last opposition a colossal dust storm obliterated much of the planet for about 10 weeks. Such storms are rare but smaller ones often blanket sections of the Martian globe. Libya, the desert region just north of Tyrrhenum, is expected to be dusty this opposition. A typical dust storm seems to wipe out detail in the affected area. Observers often think the seeing is bad when in reality 200 mile per hour winds are sweeping thousands of tons of the plentiful Mars dust high into the thin atmosphere of this fascinating world. (In such instances the seeing is bad on Mars!)

Generally the Martian air is quite transparent allowing detailed scrutiny of the surface. In past decades amateur astronomers have made thousands of drawings of Mars usually showing more detail than the drawing on page 29. At one time these observations were coordinated by national and international astronomical societies as a way of monitoring changes in the appearance of the quasi-permanent surface features. Until the early '60s, modern professional observatories virtually ignored the planets and the amateur efforts were truly of scientific value.

Today only the naive optimist will insist that the average amateur astronomer can make observations of Mars that are of any value to science. Observatories around the world have formed a network that results in almost continuous photographic coverage during every opposition of Mars. These photos equal the resolution of an eight inch telescope in the hands of a highly skilled observer — and photos are far more reliable than drawings. Hence the demise of amateur "scientific" observing (at least as far as Mars is concerned).

But do any of our readers expect to make contributions to science by spending an evening Mars-watching? Certainly not! (At least they shouldn't.) And who cares anyway? The thrill of seeing Solis Lacus or a fleeting glimpse of a canal are our rewards. The thought that the great Nix Olympica volcano is right there between Tharis and Amazonis is enough to fire anyone's imagina-



This color picture of Mars shows more detail than any earth based picture of the planet. It is a reconstruction of three television images taken by Mariner 7 when it was about 30,000 miles from Mars in 1969. The south polar cap is prominent as is Meridiani Sinus and Margaritifer. Part of the picture was not received because data from other Mariner experiments was being transmitted at the same time.
(Photo courtesy of Jet Propulsion Laboratory)

tion. The new knowledge of Mars revealed by the television eyes of four Mariner space probes have shown the planet to be an exciting varied world that remained unrecognized during centuries of earthbound investigation.

The value in recording your observations in a drawing is that later you can look back and see your own evolution as you gained experience and familiarity with the planet. You can make a map of the entire planet from a series of drawings and you can compare your drawings with those made by other amateurs. Use a two inch circle and a soft pencil to sketch in what you see. Make detailed notes of the intensity of the features. Note whether they were easy or hard to see. Record the time and date so you can calculate the C.M. It's better if you refrain from consulting a map until after the drawing is made (to discourage seeing what you expect to see).

If you prefer not to record your observations in a drawing, make note of which features you can see using the map as a guide. Don't expect to see the two moons of Mars — they're much too small for most amateur scopes. Keep in mind the diameter of the disk of Mars. The weeks around mid-October are the prime observing periods. ASTRONOMY will be publishing a selection of amateur and professional observations of Mars in future issues.

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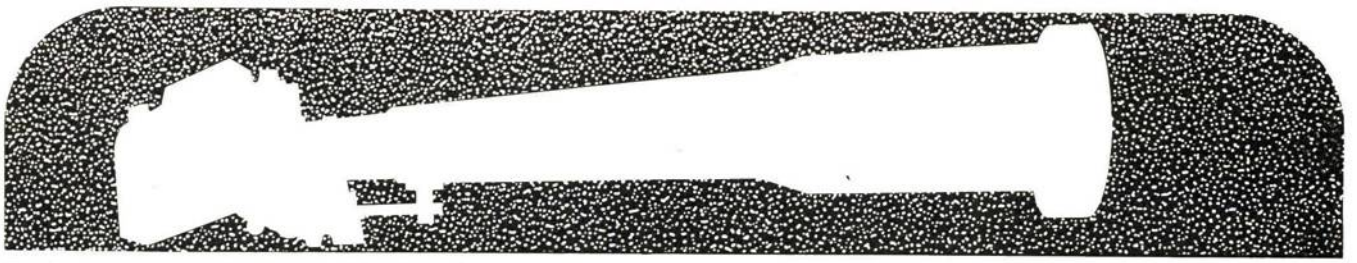


PHOTOGRAPHY IN ASTRONOMY

FILM: A Grainy Dilemma for Sky Shooters

by

John Sanford

One film for all applications — a photographer's dream, a sky shooter's utopia. Unfortunately, there ain't no such animal!

Choosing the film that's "right" for any given celestial object is difficult; poor photographs are due, in most cases, to faulty film choice rather than equipment or photographer failure.

The sky abounds in a variety of objects — the sun, moon, planets and stars — and each requires special film treatment. Let's examine each of these objects in detail.

Sun

Sol is the only object that has light to spare. The sun's surface is more than 10 thousand times brighter than sunlit gray rock. As a result, both the sun's brightness and heat must be greatly reduced to allow reasonably short exposures. The answer, of course, is a special sun filter placed over the "sky" end of the telescope tube. This method reflects away most of the sun's light and heat before it enters the telescope. Furthermore, due to the sun's basic intensity and even greater intensity at the focus of a telescope, a filter placed at the camera end of the telescope would shatter or melt causing irreparable damage to the camera.

Obviously, an ill-timed glimpse through the camera view finder could have tragic consequences.

(Safe, dependable and reasonably priced visual/photographic sun filters may be obtained from Roger W. Tuthill, 11 Tanglewood Lane, Suite 9A, Mountainside, N.J. 07092. These are designed for use over the sky end of the telescope tube.)

Once the sun's brilliance is reduced, there is still ample light to use slow, fine grain film. To record the variety of fine solar detail — sunspots, faculae (bright spots near the edge of the solar disk) and limb darkening — high resolution film should be used. Among black and white films, Kodak Panatomic-X and High Contrast Copy work well, as do H & W Ultra Pan and Kodak Monochrome Micrographic (SO-410). For color, Kodachrome II (ASA 25) is both popular and easily available. The recently introduced Ektachrome Micrographic (SO-456 at ASA 16) may be interesting to experiment with. It provides sharper images than Kodachrome II, but has little exposure latitude, and must be exposed within ½ an f/stop for best results. Slides obtained with SO-456 may not be as pleasing as with Kodachrome II due to the lower density maximum of the new film. The result is a brighter sky background surrounding the solar disk which may not be aesthetically desirable.

When recording smaller areas of the sun, such as sunspot groups, faster film is required. Magnification is the key here. For whole disk solar photography, the telescope primary (mirror or objective lens) alone acts as the "camera" lens. The camera's focal ratio is determined by dividing the telescope's focal length by its aperture. To record sunspot detail an eyepiece projection system is necessary to magnify the image. Since the telescope aperture remains static, any magnification increases the telescope's f/value and decreases the amount of light reaching the film.

The gossamer beauty of the summer Milky Way (at right) was captured with a wide angle (24mm at f/2.8) lens centered on the constellation Scutum. During the 16 minute exposure on Tri-X film, John Sanford guided his camera on an eight inch Celestron telescope.

Photograph by John Sanford

Since exposures must remain fairly short (1/60 second), the problem is solved by using faster film such as Ektachrome-X (ASA 64), High Speed Ektachrome (ASA 160), Plus-X (ASA 125) or Tri-X (ASA 400).

Moon

Small telescopes, 60mm to 6 inches aperture, are well suited to whole disk lunar photography.

The most important consideration here is a solid mounting and tripod. If the telescope has the "shakes" when used visually, it will not produce sharp moon negatives. An equatorial mount and clock drive is not essential, although it may be desirable with long exposures of the thin crescent moon.

Again, slow, fine grain film may be used. Also, film may be exposed as if you were photographing gray rock by sunlight in the garden. (Essentially we are photographing grayish rock by sunlight, except it's 240,000 miles away.) At prime focus, exposures will vary between 1 and 1/60 of a second, depending on film speed, telescope f/value and lunar phase.

The Rosette Nebula in the constellation Monoceros (below) was captured here on Ektachrome-X during a 10 minute exposure. A Celestron Schmidt camera was used at f/1.65.

EXPOSURE CHART

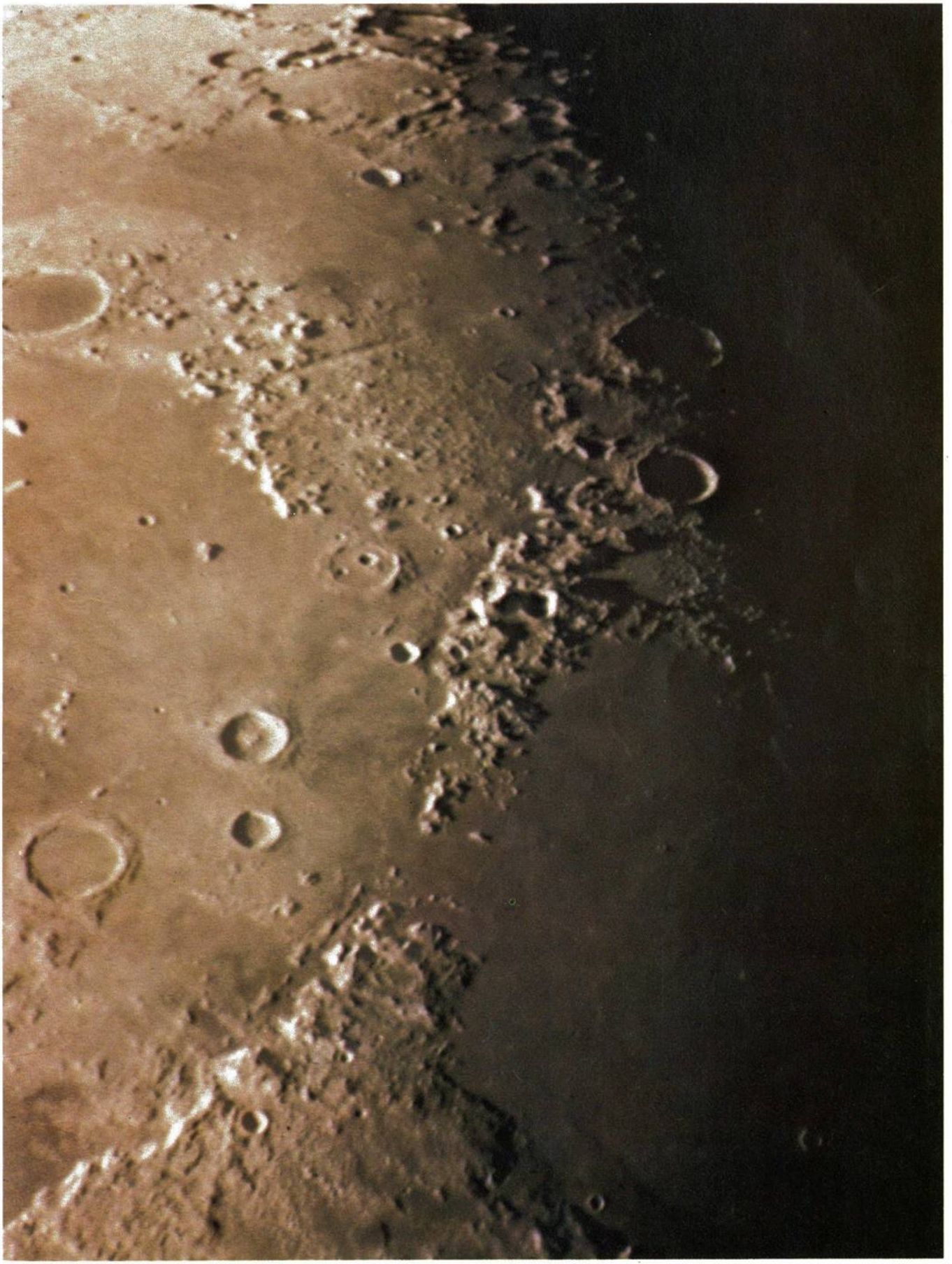
High Contrast Copy Film

Estimated Index (E.I.) 16

Exposures in seconds at telescope focal ratio:	Lunar age in days 2-4	5-8	9-18	19-22	23-26
f/6	1/8	1/15	1/30	1/15	1/4
f/8	1/4	1/8	1/15	1/8	1/2
f/11	1/2	1/4	1/8	1/4	1
f/16	1	1/2	1/4	1/2	1

Successful close-ups of lunar mountains and craters, as in the photograph at right, require an optical projection system to provide a magnified image, and a clock drive to counteract the earth's rotation. This photograph was made with a 12 inch reflecting telescope on High Speed Ektachrome. Using eyepiece projection, the effective focal length (efl) of the telescope was increased to 240 inches.

Photograph by John Sanford



Photograph by John Sanford

High Contrast Copy film should be developed in Kodak D-76 plus Crone Additive to obtain high resolution negatives which may be enlarged to 15 times original size without showing grain. For example, a 50 inch focal length telescope produces a lunar image ½ inch in diameter. This image may be enlarged to eight inches without loss of definition.

When recording individual craters or lunar mountains, magnification is required and a fast film must be used. Even if the telescope is equipped with a clock drive, exposures must remain short to minimize the effects of turbulent atmosphere (seeing). Fast films such as Kodak Tri-X, High Speed Ektachrome and GAF 200 or 500 are the wisest choices for large scale lunar photography.

Planets

Photography of the planets requires a telescope with an aperture of at least six inches. Since image scale is small at prime focus, eyepiece projection methods are necessary to produce a reasonably large image on the film.

Here we find a severe trade-off between magnification and exposure. Because of film grain, a planetary image must be enlarged to a point where detail on the planet's disk is larger than the clumps of silver grain in the film emulsion. Further, a large image requires less enlargement in the darkroom and therefore shows less film grain. A large planet image necessitates magnification. Magnification increases f/value, and f/value decreases light. Decreased light means more exposure. Longer exposures increase the probability that guiding errors and atmospheric turbulence (seeing) will be more evident. With guiding errors and poor seeing conditions more evident, detail in the planet's disk may be decreased.

While this may seem like a vicious circle, a happy compromise can be found through experimentation. Keep in mind that exposures will vary between 1 and 10 seconds.

Try using Kodak Tri-X, High Speed Ektachrome or GAF 500. And remember, only on nights when seeing conditions are best will you be able to produce the best negatives or color slides.

Stars

Photography of stars, star clusters and nebulae falls into two categories. In the first, a camera is mounted on a telescope and the telescope with

Photograph by John Sanford

Because of their large size, favorite planetary targets for the astrophotographer are Venus, Jupiter and Saturn. The photographs above were all made on Kodak High Contrast Copy film. At left, Venus was photographed during the daylight. This one second exposure was made through an eight inch telescope. Using the same telescope, a two second exposure shows the mighty planet Jupiter as it might look in a six inch telescope. The famous red spot is clearly evident in the upper right portion of the disk. At right, the ringed planet, Saturn, often difficult to capture on film, was photographed with a 12 inch reflector telescope at f/10. Comparable or better results may be obtained using Kodak Tri-X and High Speed Ektachrome film.

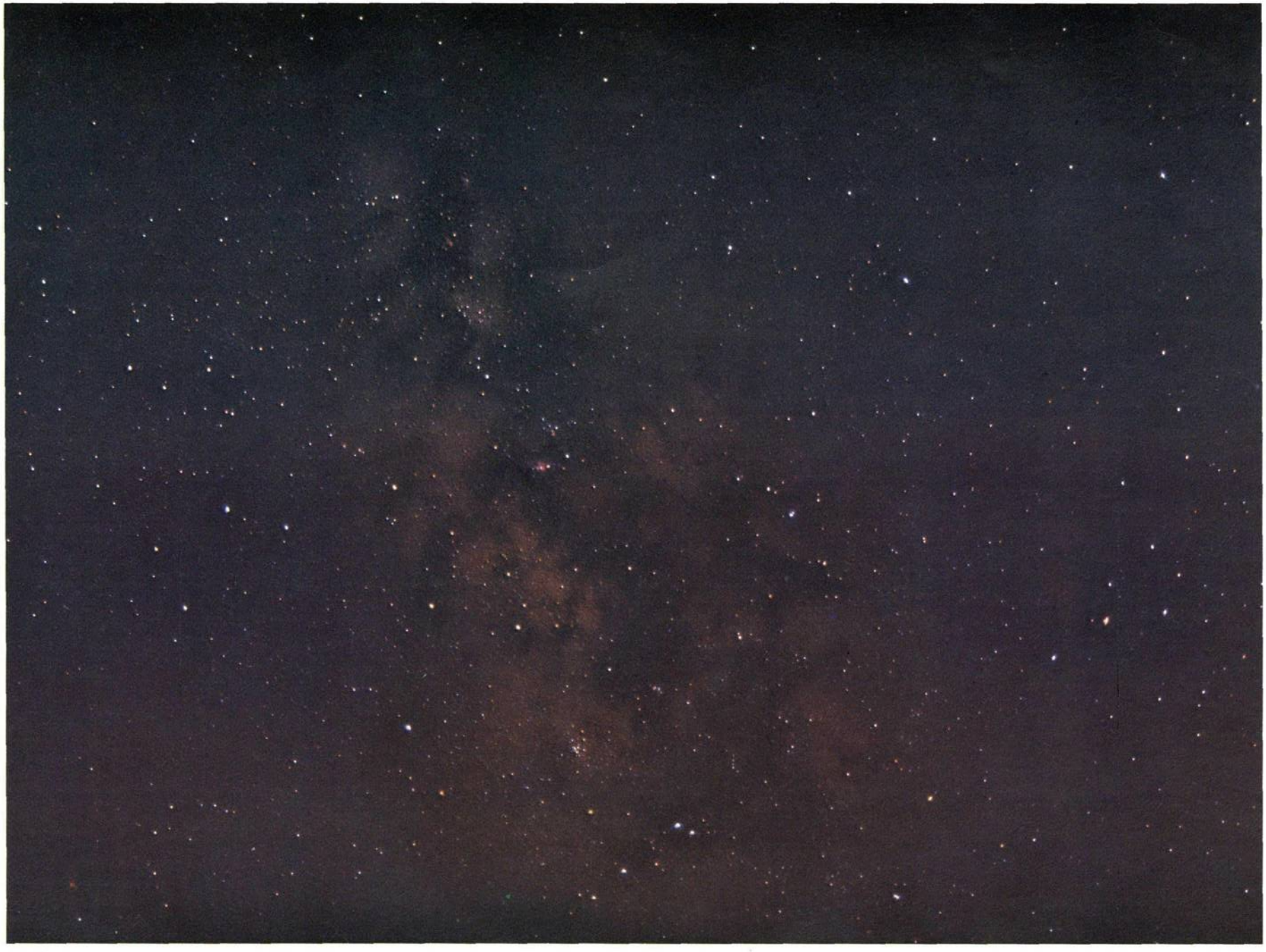
Photograph by John Sanford

The Pleiades, also known as the Seven Sisters, shine brilliantly in the winter sky. While six or seven stars are visible to the unaided eye, this photograph reveals many more. These very hot, young stars are still surrounded by the interstellar gas which gave them birth. Some of this nebula is faintly visible around the brighter stars. A Celestron Schmidt camera at f/1.65 was used to record this five minute exposure on Tri-X film.

eyepiece is used as a guider. In general, the camera lens has a short focal length — in the 24 to 50mm range — and is able to photograph wide, constellation-size areas of the sky. In the second category, called prime focus photography, the camera body (without lens) is attached to the eyepiece end of the telescope. The telescope objective lens or mirror is then used as the camera lens. Since telescopes have long focal lengths, they provide a magnified view of a small area of the sky. In both cases, exposures vary from several minutes to several hours in length.

Unfortunately, all commercially available films suffer from a common ailment — reciprocity failure. This means that film becomes less and less sensitive to light the longer it is exposed. Fast black and white films such as Tri-X, GAF Super Hypan (ASA 500), and Kodak 2475 and 2485 are designed for earth based photography requiring exposures between 1 and 1/2000 of a second. In astrophotography, where we depend on light to "pile up" in the emulsion during long exposures, earth based films lose their light gathering efficiency.

North

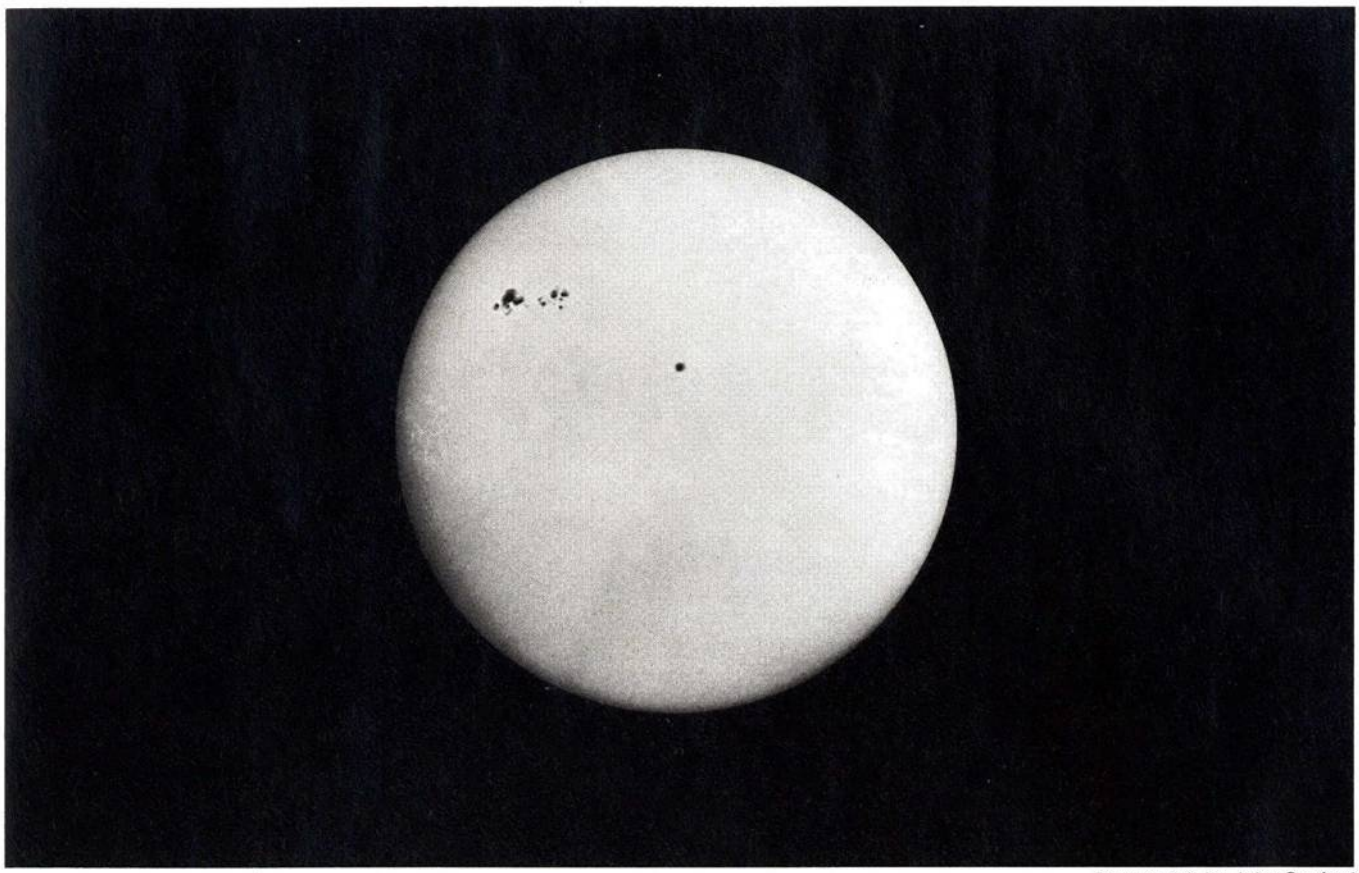


East

West

South

Photograph by John Sanford



Photograph by John Sanford

The sun is the only celestial object with light to spare. A solar filter used over the sky end of a Celestron eight inch telescope reduced the sun's brilliance and heat to allow the above photograph. High Contrast Copy film was used with an exposure of 1/125 of a second. Close-ups of sunspots require faster film and longer exposures.

This is also essentially true for color films, except the situation is complicated by the fact that color film is composed of three different emulsion layers. Each layer — red, green and blue — has a different rate of reciprocity failure.

Eastman Kodak Company manufactures several black and white films specifically for astrophotography. These spectroscopic emulsions — Kodak 103a-O, 103a-F and 103a-E — have less reciprocity failure than regular films, and are designed for exposures exceeding one minute in length. For example, in a 10 minute test at the same f/stop, Kodak 103a-F produced star images one magnitude fainter than Tri-X.

(When ordering this film from Eastman Kodak it is necessary to purchase a minimum order of 16 rolls, 35mm by 100 feet in length. However, OPTICA b/c Company, 4100 MacArthur Blvd., Dept. 9A, Oakland, Calif. 94619, sells individual rolls (35mm x 100 feet) at $28.50 per roll including airmail shipping. The rolls conveniently fit bulk film loaders for rewinding onto 35mm cassettes.)

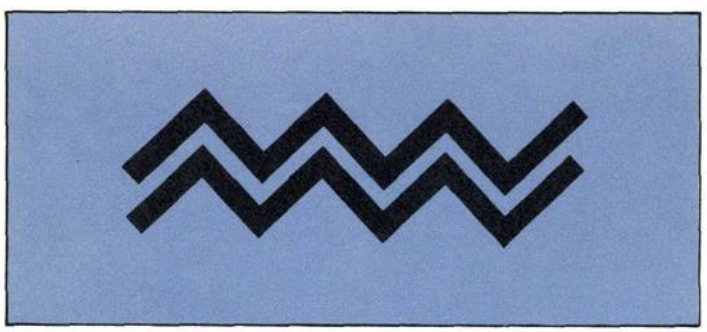
Unfortunately, only cooled emulsion cameras seem to solve reciprocity failure in color films. However, GAF 200 and 500 seem to function quite well up to exposures of 20 minutes. These films show more faint, diffuse detail (as in the Milky Way) than does High Speed Ektachrome.

New films are constantly being introduced, and improvements are being made in existing emulsions. With each introduction and improvement, sky photographers may look forward to better results.

The Star Clouds of Sagittarius are revealed here in colorful splendor. We are looking toward the center of our Milky Way galaxy where ancient stars predominate. Thousands upon thousands of old stars cluster densely into ruddy clouds that never blow away. Dark lanes interweave the Star Clouds — dust in the heart of our galaxy forever obscuring Earth's view of its very center. Using a 35mm lens at f/3.5 during a 25 minute exposure on High Speed Ektachrome, John Sanford captured some of the poetry of the universe and music of the stars.

CONSTELLATION CLOSE-UP

AQUARIUS



by

Thomas C. Bretl

Bicycle camping through less populated areas of your state provides an excellent opportunity to trace out fainter constellations such as Aquarius. Not only are skies so dark that the stars look excitingly brilliant without telescopic aid, but the leisurely, relaxed spirit of such a trip is especially conducive to patience — a necessary attribute for faint constellation hunters.

In spite of its faintness, away from city lights the patterns of stars forming the Water Carrier are easily found (see Star Dome). With a little imagination you can even see the bent over stick figure of a man running with a water filled vessel, spilling it as he runs. (This figure is illustrated in **The Stars** by H.A. Rey.)

For an observer with a small telescope, Aquarius offers a varied assortment of interesting objects, highlighted by two planetary nebulae. The Saturn Nebula, an extremely curious looking object in observatory photographs, lies near the western end of the constellation one degree west of Nu Aquarii. At eighth magnitude, it is difficult to find because its small size seems starlike under low magnification. In a six inch telescope at a magnification of 150x, however, this planetary nebula appears like a small bluish disk, much like a dim planet. The resemblance to Saturn is suggested in 8 to 10 inch scopes, but more intricate and subtle detail is lost except in photographs and very large instruments.

About one degree west of Upsilon Aquarii lies the Helical Nebula. At a distance of 590 light-years, it is the closest planetary nebula to our solar system. Here observers will encounter the opposite observing problem. Although it is fairly bright at seventh magnitude, this nebula is very large and contrasts poorly with the sky background. It appears as a faint cloud in a six inch telescope, much like some of the larger galaxies. Consequently, it is very easy to overlook. Low power, a wide field of view and dark-adapted eyes are a must to view the Helical Nebula.

Two contrasting globular star clusters are also found in Aquarius. Messier-72, next to a sixth magnitude star, is just three degrees southwest of the Saturn Nebula. Though easy to find

in a six inch telescope, it is quite small and faint. Despite the fact that it belongs to a loosely packed group of class IX globulars, M-72 is difficult to resolve. On the other hand, four degrees north of Beta Aquarii is a much brighter, more popular globular, M-2. Reputed to be an exceptionally fine object for large telescopes, this globular cluster is striking in small telescopes as well. M-2 is a very compact cluster which cannot be resolved into individual stars in a six inch reflector. However, it does show the "granulated aspect" Webb mentions as the "precursor of resolution" in **Celestial Objects for Common Telescopes.**

One can hardly resist marveling at the simple, yet striking, spherical form so exemplary of the law of gravitation. As Smyth, quoted by Webb, says, "This magnificent ball of stars condenses to the center and presents so fine a spherical form, that imagination cannot but picture the inconceivable brilliance of their visible heavens to its animated myriads."

For observers interested in double stars, Aquarius again offers a small but varied selection. Zeta and 12 Aquarii are excellent stars to test the resolving power of small telescopes, while observers with larger instruments might try 51 Aquarii. With separations of 2.8 and 2.0 seconds of arc, Zeta and 12 Aquarii can be resolved with a 60mm refractor under favorable sky conditions. At a separation of only 0.7 seconds of arc, 51 Aquarii would be much more difficult and require a larger telescope.

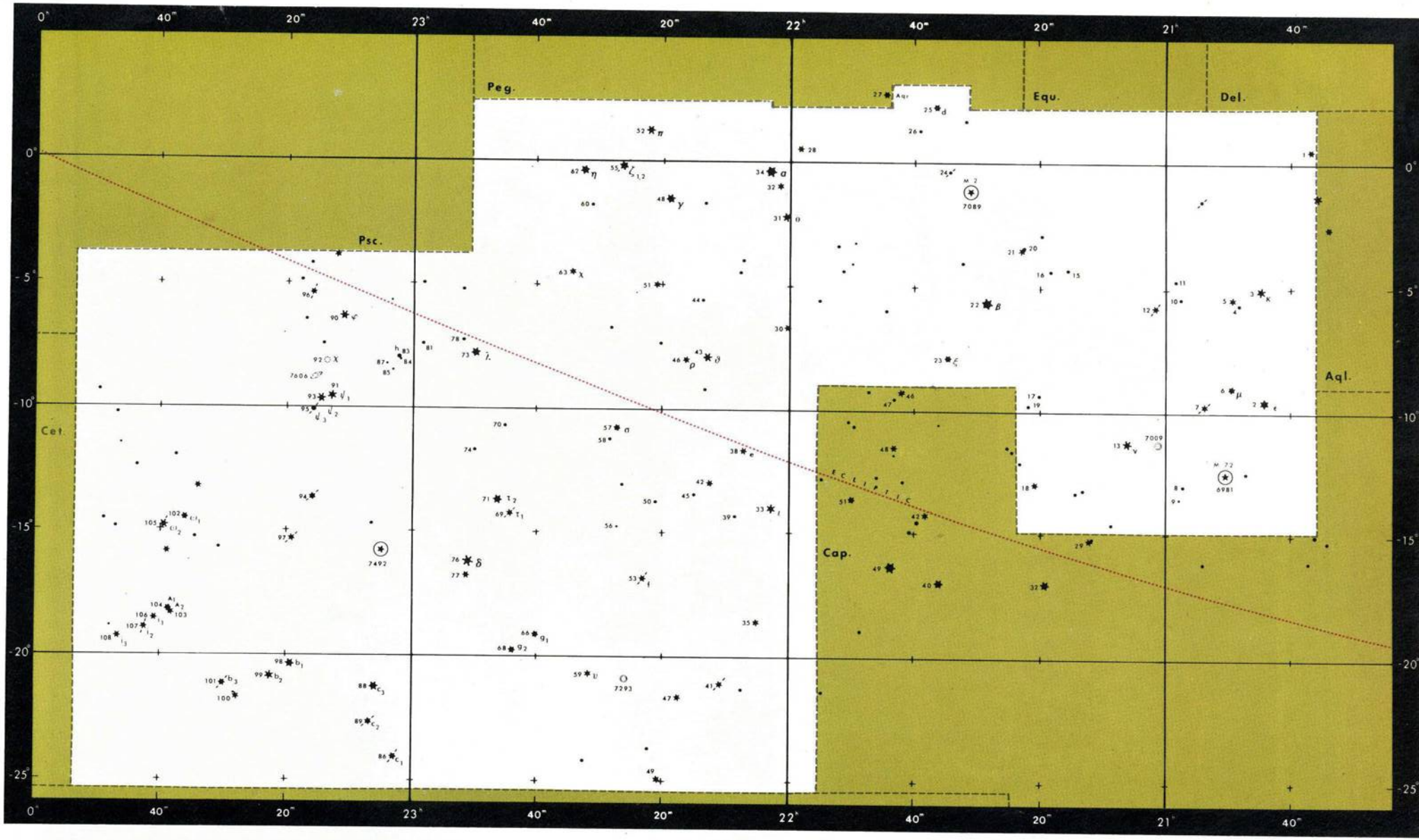
TABLE OF OBJECTS IN AQUARIUS

Nebulae and Clusters

NGC	Object Messier	Herschel	Mag.	Size	R.A.	Dec.
Planetary Nebulae:						
7009		H IV 1	8	25" x 17"	$21^h 02^m$	-11°30' (Saturn Nebula)
7293			7	15' x 12'	22 28	-21 00 (Helical Nebula)
Globular Clusters:						
6981	M 72		10	2.0'	20 52	-12 39
7089	M 2		6	8.2'	21 32	-00 58

Double Stars

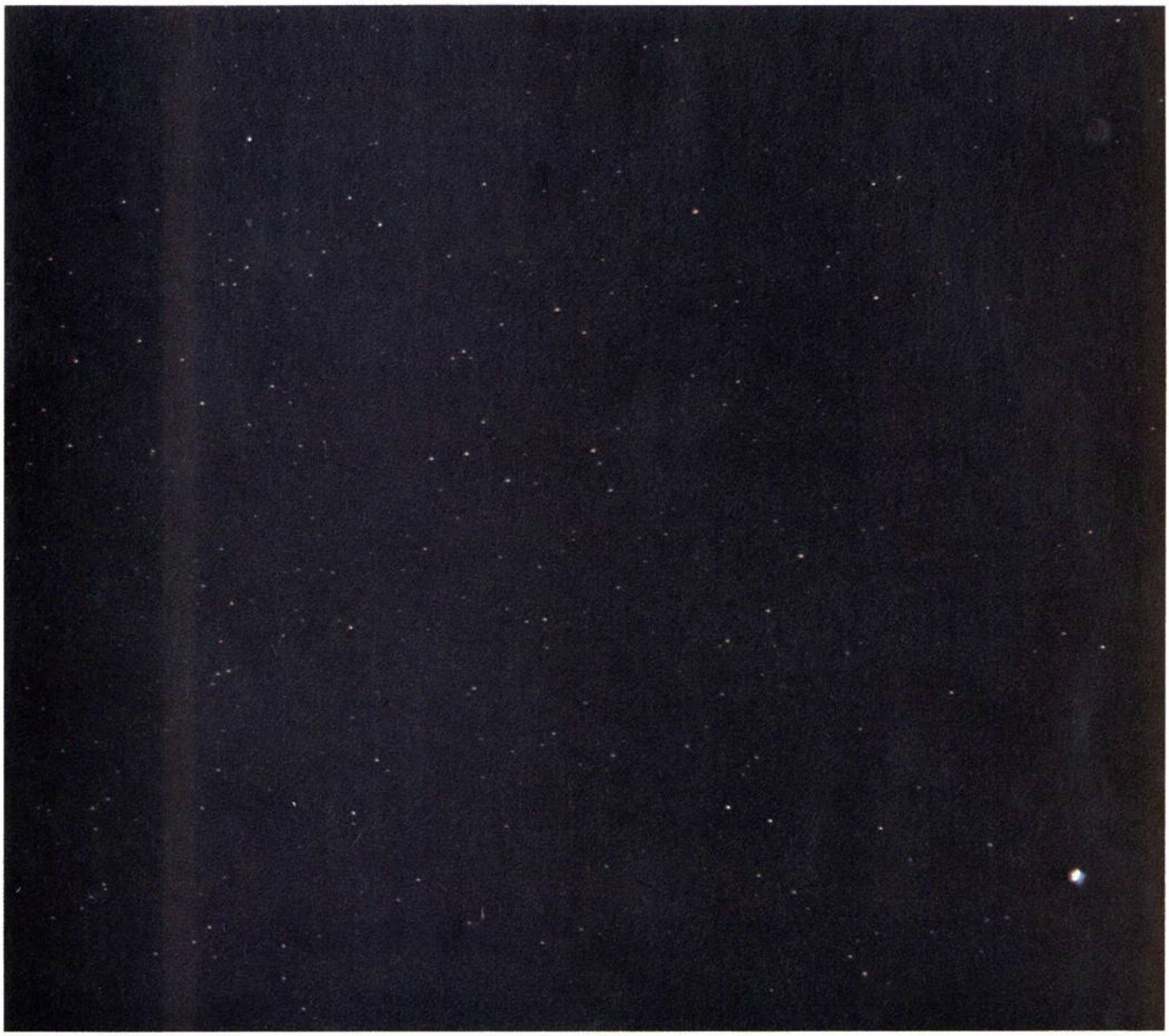
Star	Magnitudes	Sep.	Colors	R.A.	Dec.
12	6.0 - 8.1	2.8"	Yellow-blue	21 02	-05 56
41	5.7 - 7.2	5.0	Yellow-blue	22 14	-21 13
51	5.6 - 5.7	0.7		22 23	-05 00
	4.4 - 4.6	2.0	White-yellow	22 27	-00 11
94	5.2 - 7.2	13.3	Yellow-blue	23 17	-13 38



Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula Double Stars Variable Stars

Galaxies Planetary Nebula Open Star Clusters Globular Clusters



Aquarius photograph by John Sanford

In the eastern end of the constellation, 94 Aquarii is especially colorful. Easily seen at a separation of 13 seconds of arc, the components of this double star are a subtle, beautiful yellow and blue.

The constellation Aquarius is also noted for two fairly prominent meteor showers each year. These are the Eta and Delta Aquarids, named for the stars from which the showers seem to radiate. The Eta shower occurs around May 4 each year, while the Delta Aquarids take place July 28. During both showers, observers should see about 20 meteors per hour.

It has been claimed that these Aquarian objects are not very spectacular — whether seen from a campground or a backyard. It has also been claimed that Jupiter, Saturn and the moon are really the only spectacular objects that can be seen through a small telescope. Frankly, this is much like saying that main roads and superhighways are best for bicycling because they make the bike go faster and enable the rider to see and do more things.

Superspectaculars, like superhighways, often miss the point. If you move too fast, with eyes that demand overwhelming sights, you may bypass more beauty than you see. For there are many more subtle things in nature that require a little patience than there are gaudy spectacles. It is true across the land. It is true across the sky. One must learn to see them. Try traveling the country roads — across Aquarius!

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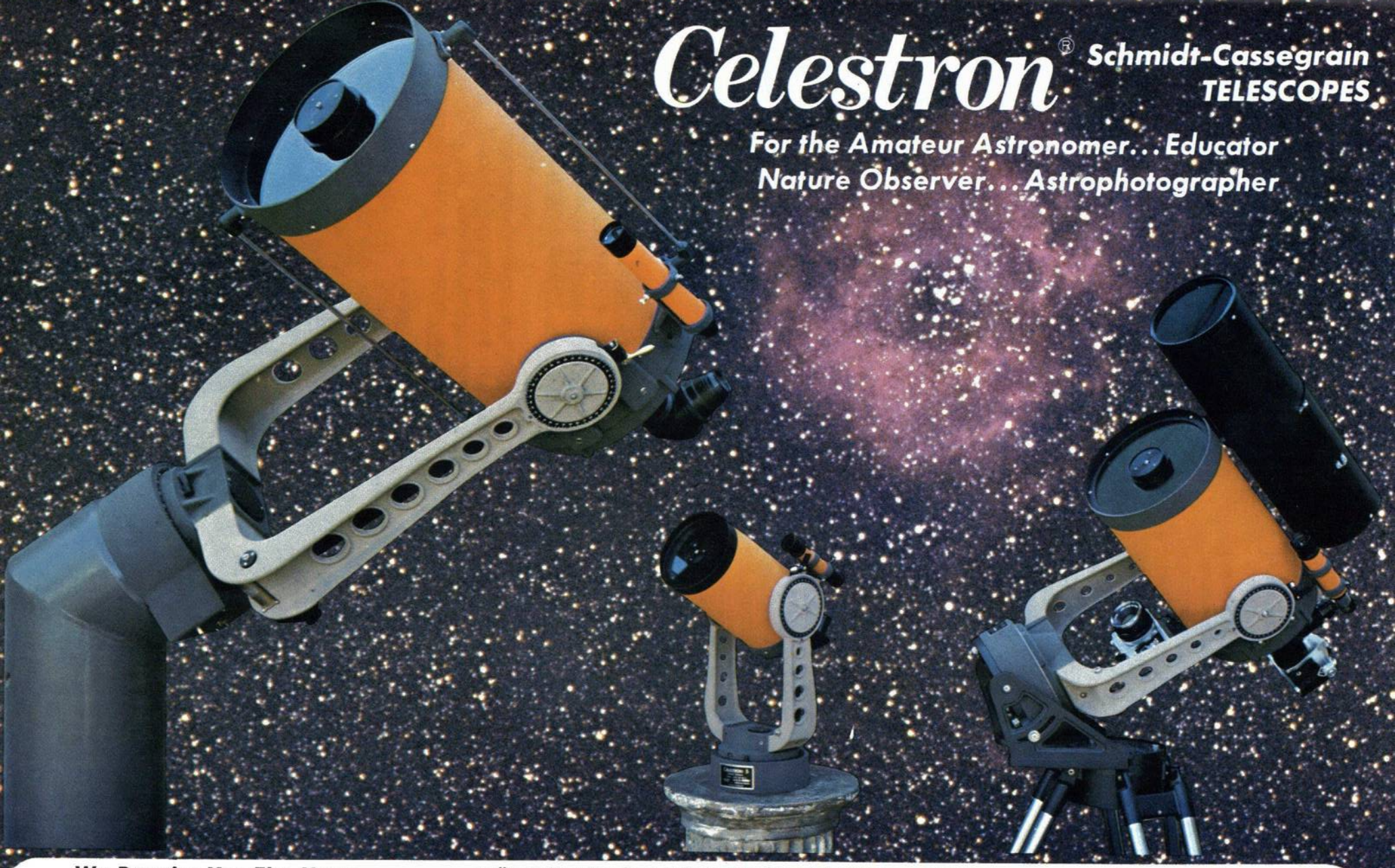

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